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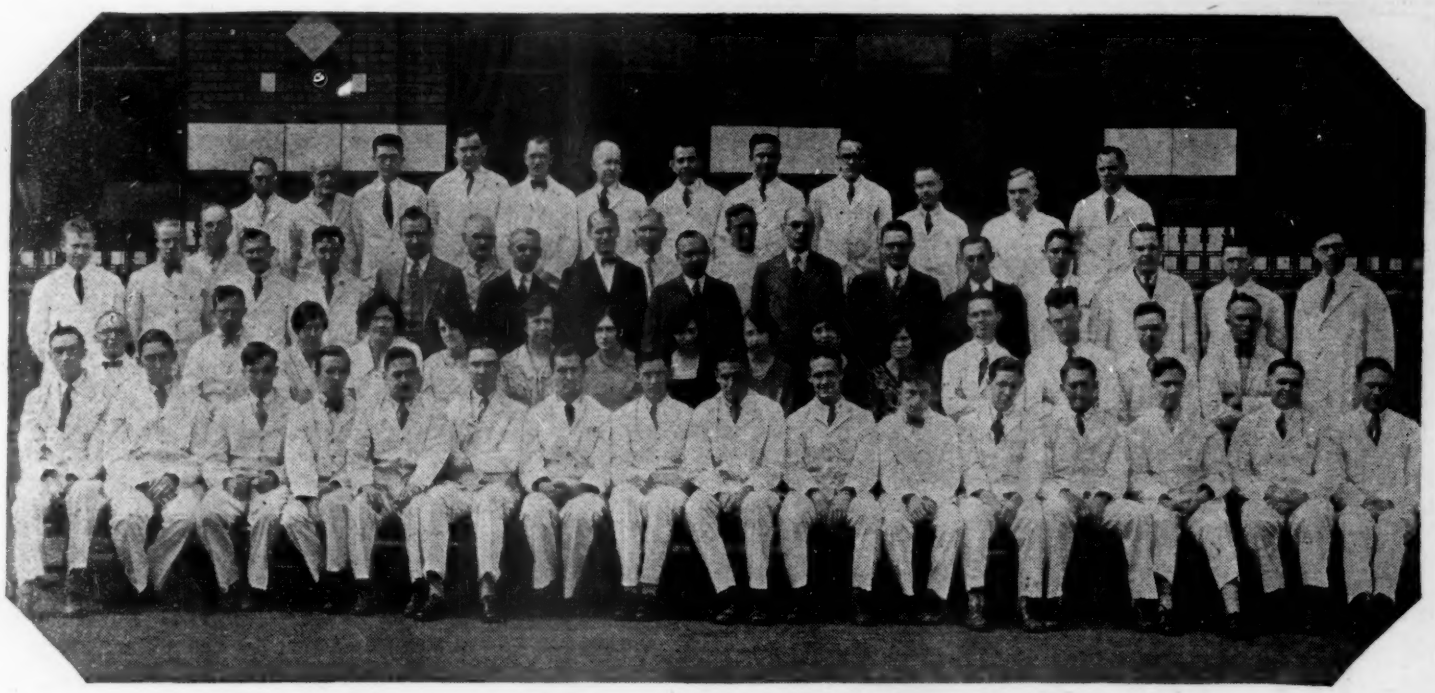

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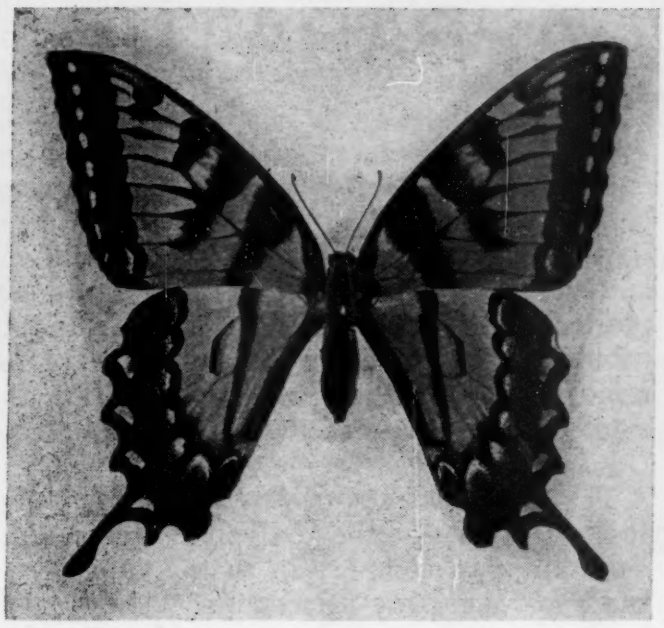

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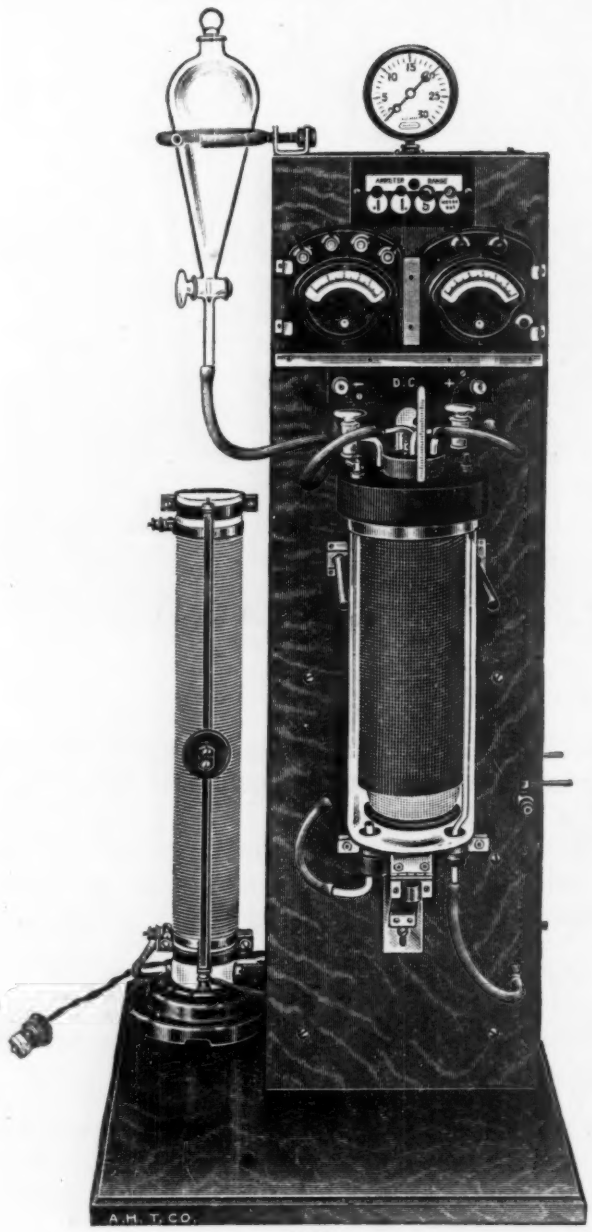

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MODERN CONCEPTS IN PHYSICS AND THEIR RELATION TO CHEMISTRY

By Dr. IRVING LANGMUIR

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ONLY about thirty-five years ago, during the nineties of the last century, knowledge of the physical sciences had advanced to such a point that many of the foremost physicists and chemists began to believe that the rate of progress of fundamental knowledge must be slowing up. The concepts of length, mass, time, energy, temperature, electric and gravitational fields, etc., had been given precise meanings and were regarded as having an absolute existence quite as certain as that of matter itself. The phenomena of nature were explainable in terms of natural laws expressing relations between these absolute quantities. It seemed that the most important of these laws of physics and chemistry had already been discovered and that the work that remained to do was largely a matter of filling in the details and applying these great principles for practical purposes.

The laws of mechanics had been verified experimentally with a high degree of precision so no one doubted that they were rigorous laws of nature. Back in about 1830 Hamilton had succeeded in generalizing these laws in a few simple equations which seemed to contain all the essential truths of mechanics. It was only necessary to know how the kinetic and potential energy of any given system varied with the momentum and the coordinates of its parts in order to have at least a formal solution of the way in which the system would behave at all times. Thus all future work in mechanics need only be considered an application of Hamilton's equations.

Complete knowledge of the nature of light presented more difficulties. Hamilton about 1820 showed that all the known laws of geometrical optics could be explained quantitatively in terms of either a cor-

puscular theory of light or a wave theory. The experiments of Fresnel on the interference of light which were made about this time seemed to disprove Newton's corpuscular theory so that Hamilton's proof of the complete analogy between waves and corpuscles in the case of geometrical optics became only of academic interest. Through the study of the phenomena of interference, diffraction, polarization and absorption of light, the wave theory of light became firmly established. Light was supposed to consist of waves in some sort of an elastic medium which was called the ether.

About 1830 Faraday developed clear conceptions regarding the electric and magnetic fields, and Maxwell about 1860, by applying exact mathematical methods, evolved the electromagnetic theory of light according to which light waves consisted of fluctuating electric and magnetic fields which are propagated through space at a speed which could be calculated from electric and from magnetic measurements in a laboratory.

Although the acceptance of Maxwell's views came slowly, one could not long remain skeptical after the production of electromagnetic waves of relatively great wave-length by Hertz in 1884. It may almost be said that Maxwell's theory was essentially an application of the mathematical methods which Hamilton had originated in his treatment of the laws of mechanics to Faraday's concepts of electricity and magnetism.

Thus in 1895 the physicists seemed to have some justification for the attitude that the most important laws had been discovered. The laws of mechanics had not been improved upon in sixty-five years. Faraday and Maxwell had brought in precise conceptions of electric and magnetic phenomena and had shown that, by classical methods like those which had been so successful in mechanics, all the laws of optics could be derived from those of electromagnetism.

In chemistry a somewhat similar state had been reached. After the evolution of the conception of the elements and of combining proportions based upon an atomic theory, rapid progress was made in accumulating data regarding the elements and their compounds. Faraday's laws of electrolysis and new methods for the accurate determination of atomic weights began to provide the chemist with quantitative laws almost as precise as those of the physicists. The work of J. Willard Gibbs had brought into chemistry rigorous laws as fundamental in their field of application as were those of Hamilton and Maxwell in physics.

These remarkable advances on the quantitative side seemed to overshadow in importance the more qualitative results that had previously been obtained through the stimulus of the atomic theory. Under the leadership of Ostwald, chemists began to adopt a much more critical attitude and to distinguish carefully between what they considered experimental facts and hypotheses based upon these facts. Ostwald, although he recognized the convenience of the atomic theory, believed that it must always remain impossible to prove the existence of atoms or molecules. He therefore urged that chemists avoid as far as possible the use of such hypotheses. Perhaps the chief result of this attitude was to lead physical chemists to neglect those parts of chemistry where the atomic theory would have been most helpful and to devote themselves more specially to the fields in which energy relationships and thermodynamics were directly applicable.

Physicists in general did not doubt the existence of atoms and molecules, but had by means of this theory developed the kinetic theory of gases which had led to many new quantitative laws, verified by experiment. However, the physicists in general had little to do with atoms and molecules but were more concerned with the ether, in which they believed unreservedly, although direct knowledge of the ether was far harder to obtain than knowledge of atoms and molecules.

Perhaps one of the main reasons why the physicists were so sure of the ether and the chemists so doubtful of the atoms and molecules was an unconscious belief in the respectable old adage "Natura non facit saltum," Nature makes no jumps. Certainly in those fields of physics and chemistry in which rigorous quantitative laws had been found applicable no discontinuities or jumps such as those implied by the atomic theory had been found.

The discovery of X-rays by Roentgen in 1905 marked the beginning of an extraordinary revolution which is to-day still in progress. This sensational event revealed to the physicist that great and fundamental discoveries were still possible even in the field of radiation where physics had had such complete success. It immediately caused great numbers of physicists to study the phenomena of electric discharges and to look for other sources of radiation. The discovery of radium and radioactivity by Becquerel and the Curies soon showed the importance of these new forms of radiation to the chemist as well as to the physicist.

Although Stoney in 1874 had seen that Faraday's laws of electrolysis together with the atomic theory required that electricity should also have an atomic structure, and although in 1891 he proposed the name electron for these atoms of electricity, J. J. Thomson should be regarded as the discoverer of the electron. He was able to show that electrons were contained in all forms of matter and found that the electron

must weigh only about 1/1800 as much as a hydrogen atom.

The studies of radioactivity, largely by Rutherford and his students, showed that radium spontaneously disintegrated to form helium and proved to the chemist that atoms were not indestructible and even that transmutation of elements was possible.

By the application of thermodynamics to radiation processes Boltzmann proved that the total radiation, of all wave-lengths, within a cavity in a heated body must increase in proportion to the fourth power of the absolute temperature; this law had already been found empirically by Stefan. By a further development of thermodynamic methods, Wien in 1896 derived an important law, known as Wien's law, by which the intensity of radiation of any particular wave-length could be calculated in terms of the wave-length and temperature. This law was found to agree with experiment in the case of visible radiation from incandescent solids, but serious discrepancies were observed when an attempt was made to calculate the intensity of infra-red radiation or heat waves. Lord Rayleigh and Jeans in 1900, using what seemed to be unimpeachable methods based on the electromagnetic theory of light, arrived at an entirely different relation between the intensity of radiation and the temperature and wave-length. This equation agreed excellently with experiments on the radiation of heat where Wien's law had failed but led to absurd results when applied to the shorter wave-lengths of the visible spectrum. In fact, if the total radiation including all wave-lengths was calculated from the Rayleigh-Jeans equations an infinite radiation density was obtained even at low temperatures. Thus by means of the classical theories of radiation it was found on the one hand by Boltzmann that the radiation increased with the fourth power of the temperature, and on the other by Rayleigh-Jeans that the radiation was infinite at all temperatures.

It was shown in 1905 by Planck that this paradox could be solved only by assuming an essential discontinuity in the energies or motions of electrons whose vibrations caused the radiation. This gave birth to the quantum theory which within recent years has grown to be one of the most important theories of physics and chemistry. In 1906 Einstein showed that the photoelectric effect and many photochemical reactions could be explained in terms of the quantum theory if light itself consisted of discrete particles of energy, or quanta, now usually called photons. Although such a corpuscular theory of light seemed utterly incompatible with the accepted wave theory, an increasing number of phenomena were discovered in which it seemed necessary to resort to this corpuscular theory. The really rapid development of the quantum theory, however, dates from 1913 when Bohr began to develop his theory of atomic structure by applying the quantum theory to Rutherford's more or less qualitative theory of the nuclear atom.

Relativity theory.—Among all the changes in the ways of thinking which were being forced upon physicists at this time, the most important by far was that which resulted from Einstein's relativity theory, first stated in 1905. In 1895, as we have seen, electromagnetic waves and matter were thought to be manifestations of the properties of an all-pervading ether.

As an example of the way that the physicists thought of the ether I will quote from the preface to Lord Kelvin's "Baltimore Lectures." This preface was written in 1904, but the lectures were those that were delivered at the Johns Hopkins University in 1884:

> I chose as subject the wave theory of light with the intention of accentuating its failures, rather than of setting forth the admirable success with which this beautiful theory had explained all that was known of light before the time of Fresnel and Thomas Young, and had produced floods of new knowledge splendidly enriching the whole domain of physical science. My audience was to consist of professional fellow-students in physical sciences. . . . I spoke with absolute freedom and had never the slightest fear of undermining their perfect faith in ether and its light-giving waves; by anything I could tell them of the imperfection of our mathematics; of the insufficiency or faultiness of our views regarding the dynamical qualities of ether; and of the overwhelmingly great difficulty of finding a field of action for ether among the atoms of ponderable matter. We all felt the difficulties were to be faced and not to be evaded; were to be taken to heart *with the hope of solving them if possible.* . . . It is in some measure satisfactory to me and I hope it will be satisfactory to all my Baltimore coefficients still alive in our world of sciences, when this volume reaches their hands to find in it dynamical explanations of every one of the difficulties with which we were concerned from the first to the last of our twenty lectures of 1884. All of us will, I am sure, feel sympathetically interested in knowing that two of ourselves, Michelson and Morley have by their great experimental work on the motion of ether relatively to the earth, raised the one and only serious objection against our dynamical explanations.

This Michelson and Morley experiment of 1887, through the theoretical investigations of Lorentz and others, kept growing in importance until it finally stimulated Einstein to evolve his relativity theory.

According to this theory space and time can not be considered as existing independently of one another. They can not in any sense be regarded as absolute but are both dependent upon the point of view of the observer. For example, Einstein showed that it has no meaning to say that two events which took place at a

great distance apart occurred simultaneously. Some observers knowing of both events would have to say that event A occurred before B, while other observers moving at a different velocity from the first observers would conclude that B occurred before A.

It is not my plan to try to explain the relativity theory to you even if I knew how to do so, but it is rather to discuss the way in which this theory and others of a somewhat similar nature have gradually brought about profound changes in the view-point of the physicists and how similar changes are beginning to occur in the attitude of the chemists. The importance of Einstein's work thus lies not so much in the facts or phenomena that can be explained by the relativity theory as in the discovery of a new way of thinking as applied to physics. Somewhat similar methods of thought had, it is true, been used in some branches of mathematics and sometimes in philosophy, but Einstein subjected our elementary conceptions of space, time, mass, energy, etc., to a searching analysis quite new in the history of physics.

Concepts involve operations.—Professor P. W. Bridgman, of Harvard University, has recently written a popular book entitled "The Logic of Modern Physics" in which he analyzes the changes in our concepts that have resulted primarily from Einstein's work. Bridgman's thesis is that physical concepts have meaning only in so far as they can be defined in terms of operations. He shows that this new attitude towards our fundamental conceptions is perhaps one of the greatest changes that have been brought about by Einstein's work. There is no question in my mind but that the recent remarkable advances in quantum mechanics that have been made by such men as Bohr, Heisenberg, Schroedinger and Dirac have been stimulated by the desire to formulate all concepts in terms of operations. Bridgman has not originated this method, but he, more than any one else, perhaps, has been conscious of its wide-spread application in modern physics.

I should like to outline to you the way in which Bridgman develops this thesis and to consider how well it applies to the most recent changes that have taken place in physics and in chemistry. I believe the chemist can derive great benefit from the conscious application of a similar critical attitude in his own science.

Bridgman points out that "hitherto many of the concepts of physics have been defined in terms of their properties." An excellent example is Newton's concept of absolute time. The following quotation from Newton's "Principia" is illuminating:

> I do not define Time, Space, Place or Motion, as being well known to all. Only I must observe that the vulgar conceive those quantities under no other notions but from the relation they bear to sensible objects. And thence arise certain prejudices, for the removing of which, it will be convenient to distinguish them into Absolute and Relative, True and Apparent, Mathematical and Common.
>
> (1) Absolute, True and Mathematical Time, of itself, and from its own nature flows equably without regard to anything external, and by another name is called Duration.

Thus, according to Newton, time and space have properties of a very abstract kind and are looked upon as "things" which exist independently of all other things. There is, however, as Bridgman says, "no assurance whatever that there exists in nature anything with properties like those assumed in the definition, and physics, when reduced to concepts of this character, becomes as purely an abstract science and as far removed from reality as the abstract geometry of the mathematicians." Nevertheless, these conceptions of space and time prevailed until the relativity theory was proposed.

In the development of his theory Einstein, in analyzing the concepts of space and time, considered what means are available by which an observer can measure distances between two points on a rapidly moving object. For example, imagine two planets moving past one another at high velocity, and two observers, one on each planet, provided with means for observing each other and communicating with each other; such means, for example, as light signals. Einstein asks, what are the operations by which the two observers could compare their units of length and time. He finds that each observer would logically conclude that the other observer's unit of length is shorter than his own, and that the other's unit of time is longer than his own. Einstein thus proved that there can be no such thing as absolute length or time, or rather proved that the concept of absolute time has no meaning, for we have not been able to conceive of any method for determining the absolute time of any event.

In order to illustrate his thesis Bridgman considers in detail the concept of length. Probably one of the earliest concepts of length was obtained by counting the number of unit lengths that can be placed end to end between two given objects. For example, the number of paces are counted in walking from one object to another. An extension and refinement of this method is employed to-day when the standard meter at the Bureau of Standards is compared with a steel tape and this is then used to lay off a base line for a survey by triangulation.

As Bridgman suggests, it was one of the greatest discoveries of the human race to find that these operations performed with a measuring-rod afford a useful and convenient means of describing natural phenomena.

During the transition from the earliest pacing of distances to our modern refined measurements with the meter stick the concept of length itself must have undergone radical modifications, since the operations involved had been modified. For example, if distances are to be paced, it has no meaning to consider distances of 1/1000 of a pace unless the concept is modified to include arbitrarily chosen methods by which a length equal to 1/1000 of a pace may be determined. In our modern measurements with a steel tape we must measure the temperature of the tape and the force used in holding the tape taut, and then, by means of the coefficient of expansion and the coefficient of elasticity, apply corrections to the observed length. It is hard to see what methods primitive man could have used in applying such corrections to his distances measured by pacing.

Why do we now apply such corrections? Merely because it has been found by experiment that the result that we get by applying such corrections is a quantity which proves to be more useful in describing natural phenomena than the results we get without these corrections. We must not think that we do it in order to obtain the "true" or "absolute" length.

To-day we have many other methods of measuring length than by use of measuring-rods or steel tape. For example, we use optical instruments and measure distances by triangulation; we measure heights in the atmosphere by means of a barometer; we measure the distances of spiral nebulae by measuring the brightness of the Cepheid variables observed in them by our most powerful telescopes; we measure the lengths of molecules by finding the area of a water surface over which a given amount of oil will spread; we calculate the diameters of molecules by measurements of the viscosity of gases by means of the kinetic theory or we use X-ray diffraction patterns or, finally, we calculate the diameter of an electron from its mass and charge by means of the electromagnetic theory, assuming that all the energy of the electron lies in the electric field outside of its surface.

Now each of these measurements of length involves an entirely different set of operations and therefore, fundamentally, according to Bridgman, we should regard them as different concepts; logically, in fact, they should all have different names. It has, however, been found as a matter of experiment that two or more of these methods when applied to the measurement of the same distance give results which agree more or less with one another. This, then, is our justification for calling all these concepts by the same name, length.

We may, if we wish, extrapolate and predict that by applying suitable corrections to each of these methods of measuring lengths we may be able to get better and better agreement between them. Such methods of extrapolation may be useful and stimulating, but we must always expect that sooner or later we will be unable to obtain agreement between these methods with more than a limited degree of accuracy. This may not be due merely to experimental difficulties but may often result from unavoidable fuzziness in the concept itself. Such concepts as the diameter of a complicated molecule or the mean free path of a molecule in a gas are inherently fuzzy conceptions and can mean not much more than when we speak of the diameter of a tree or of the length of the waves during a storm at sea.

Perhaps the strongest reason for the general belief in the existence of an absolute space lay in the apparently perfect agreement between our measurements of length and the theorems of Euclidean geometry. During the last century, however, mathematicians began more and more to realize that Euclidean geometry was only one out of many possible logical geometries, and since all these were based solely on certain axioms or postulates none of them had any real or necessary connection with physics. The apparent agreement between our physical observations and Euclidean geometry, therefore, does not prove that space must have the properties postulated in Euclid's axioms.

Models.—As chemists, we are all more or less familiar with various models of atoms and molecules that have been proposed within recent years. The structural formulas which the organic chemists have used for a good part of a century are another example of an extremely useful type of model. I want to discuss later some of the models which the physicists have used in giving more concrete forms to their theories. Logically, I believe, we should regard Euclidean geometry as a model devised primarily to help us "explain" natural phenomena.

Observation of nature reveals great complexity. We receive enormous numbers of impressions simultaneously, and if we are to make progress in understanding phenomena we must concentrate on certain aspects of the things we see about us and thus discard the less important features. This involves a process of replacing the natural world by a set of abstractions which we have become very skilful in choosing in such a way as to aid us in classifying and understanding phenomena. Thus it was found useful to develop concepts or abstractions such as shape, position, distance, etc., and to separate these characteristics of the phenomena from others such as color, hardness, etc. Euclidean geometry was found useful in correlating these concepts of shape, position, etc.

Physicists and chemists have usually felt that they understood a phenomenon best when they could ex-

plain it in terms of a model or concrete picture. The chemist explained the law of multiple combining proportions in terms of atoms which combine together to form molecules. The heat conductivity, viscosity, etc., of gases were explained by the kinetic theory, with molecules making elastic collisions with one another according to the laws of probability.

When we use the atomic or molecular theories to explain phenomena in this way we assign to the atoms and molecules only those properties which seem needed to accomplish the desired result; we do not consider what the atom is made of or what is its structure, but usually feel justified in assuming properties which are as simple as possible. For example, in the elementary kinetic theory it is assumed that the molecules are hard elastic spheres, not because any one really believes that molecules have these properties, but merely because these are the simplest properties we can think of which are consistent with the known facts.

What we really do, therefore, is to replace in our minds the actual gases which we observe and which have many properties which we do not fully understand, by a simplified model, a human abstraction, which is so designed by us that it has some of the properties of the thing we wish to displace.

There is thus a difference of degree rather than of kind between the adoption of a mechanical model and the development of a mathematical theory such as Euclidean geometry. When the mathematical physicist develops an abstract theory of actual phenomena, for example, Hamilton's equations to summarize the laws of mechanics, he is in reality constructing a mathematical model. Mathematical equations have certain definite properties or rather they express certain relationships between the symbols which enter them. In a mathematical theory of physical phenomena the equations are so chosen that the relation between the symbols corresponds in some simple way to that which is observed between measurable physical quantities which are the bases of our concepts of physics.

Within recent years, especially in the development of the relativity and quantum theories, physicists have been making increasing use of mathematical forms of expression, and have been giving less attention to the development of mechanical models. The older generation of physicists and chemists and those among the younger men who are less skilled in the use of mathematics are inclined to believe that this is only a temporary stage and that ultimately we must be able to form a concrete picture or model of the atom, that is, to get a picture of what the atom is really like. It seems to be felt that a mechanical model whose functioning can be understood without the aid of mathematics, even if it only gives the qualitative representation of the phenomena in question, can represent the truth in some higher sense than a mathematical theory whose symbols perhaps can be understood only by a mathematician.

There is, I believe, no adequate justification for this attitude. Mechanical models are necessarily very much restricted in scope. The relationships of their parts are limited to those that are already known in mechanics (or in electricity or magnetism). Mathematical relationships are far more flexible; practically any conceivable quantitative or qualitative relationship can be expressed if desired in mathematical form. We have no guarantee whatever that nature is so constructed that it can be adequately described in terms of mechanical or electrical models; it is much more probable that our most fundamental relationships can only be expressed mathematically, if at all.

In analyzing our attempts to describe nature, we have discussed concepts, models and mathematical theories. We find that they are all alike in that they represent human abstractions which are found convenient in describing nature. Going back a step further we must recognize that *words* themselves constitute elementary concepts. They are, it is true, much more vaguely defined than our concepts of physics and chemistry, but qualitatively they are very much like the latter, in fact, most of our misunderstandings in science arise from assigning reality to concepts whose main reason for existence is the fact that they are represented by a word. Logically we should aim to define our words in terms of operations. We should have in mind specifications by which we can test whether or not the word is properly applicable.

The progress of science depends largely upon: (1) giving to words meanings as precise as possible; (2) definitions of concepts in terms of operations; (3) development of models (mechanical or mathematical) which have properties analogous to those of phenomena which we have observed.

Meaningless Questions

A great deal of time and effort is wasted in scientific circles as well as in the world at large through failure to give sufficiently definite or useful definition of words and concepts. Bridgman emphasizes this in connection with his discussion of "Meaningless questions."

In some cases questions fail to have meaning because of the more or less inherent fuzziness of the concepts involved. For example, if we compare two trees of about the same size it may have no meaning to ask which tree has the larger diameter, for no one

has defined the diameter of a tree with the necessary precision.

A more important class of meaningless questions arises when there are no conceivable operations that could be performed to arrive at a decision. For example, what is the meaning of the question, "Would the United States have entered the World War if the *Lusitania* had not been sunk?" Such a question may be a good subject for a school debating society, but no one is apt to think that the question has thereby been answered.

A study of meaningless questions may serve a very useful purpose in science. A statement that a certain question has no meaning may be equivalent to stating a fundamental law of nature, for example, to say that the question "What is the true velocity of the North Star through space?" has no meaning is a fairly good statement of at least a part of the relativity theory.

In some cases it may have no meaning to ask whether or not there is a magnetic field in a certain portion of space. For example, suppose an observer, stationary on the earth, studies an electron in motion. The motion of an electron constitutes an electric current and experimentally he will observe the characteristic magnetic field surrounding this electron corresponding to this current. If another observer moves along with the electron, it will appear to him to be at rest, and of course he can observe no magnetic field. Otherwise, the presence or absence of a magnetic field around an electron or group of electrons could be used to determine absolute motion through space, which would be contrary to the relativity theory. The relativity theory thus requires that a magnetic field can have no real existence in any absolute sense.

We have seen that there are fundamentally as many different concepts of length as there are different ways in which length may be measured, but nevertheless we find approximate agreement between different ways of measuring the diameter of molecules and therefore are justified in assigning some *reality* to the concept diameter of molecule. When, however, we ask what is the diameter of an electron, we find that the question is practically without meaning. It is true that we can calculate a diameter by assuming that the electron behaves like a charged sphere and that the classical laws of electrodynamics can be applied in this case. However, since we have no independent way of measuring this diameter, the process is one which involves reasoning in a circle.

There are many meaningless questions which afflict the chemist. It clearly has no meaning to ask what is the molecular weight of sodium chloride in a crystal. It is very doubtful whether it has any meaning to ask what is the molecular weight of water in liquid water. There are many cases where the concept of temperature has no definite meaning. Strictly speaking, temperature acquires meaning in terms of operations only in so far as an approach is made to equilibrium conditions. When the motion of molecules or atoms follows Maxwell's distribution laws, that is, a random or probability distribution of velocity among the molecules, the concept of temperature becomes very definite. If, however, we deal with mercury vapor streaming into a high vacuum, or the conditions near a hot tungsten filament in a gas of low pressure, temperature has very little meaning. The same is true of the conditions frequently existing in an electric discharge tube such as a mercury arc where the electrons act as though they had a temperature of perhaps 50,000°, whereas the atoms have motions corresponding to far lower temperatures. Strictly speaking, neither the electrons nor atoms have well-defined temperatures, for the conditions are far removed from equilibrium.

In much of the recent discussion of the radiation hypothesis of chemical reactions, chemists have been discussing meaningless questions usually without realizing it. At first it was proposed that the radiation is absorbed by the reacting gas to form excited molecules in accordance with Einstein's photochemical law. When this is found not to be in accord with experiment, the concept of radiation is altered repeatedly as new experimental facts are found so as to make the modified theory continue to fit the facts. After this process has been carried on sufficiently it no longer has any meaning to ask whether the reaction is caused by radiation or whether the radiation hypothesis is true.

In the studies of the properties of liquids, questions of the degree of ionization and of association and in some cases of internal pressures have been discussions of questions without meaning. A great deal of such discussions might be simplified or even avoided entirely if chemists would agree in defining these concepts in terms of operations.

Theories of valence within recent years have been afflicted with the same difficulties. As long as chemists deal with the ordinary valence rules of organic chemistry, they are dealing with concepts of valence which are actually defined in terms of operations; that is, the organic chemists know how to conduct experiments to prove that the valence of nitrogen in dimethyl aniline is 3. The types of operations needed to establish the valence of magnesium in magnesium chloride are in many ways quite different, and they are still different if we consider the case of so-called quinquevalent nitrogen in ammonium chloride or heptavalent chlorine in perchloric acid. I believe

that the chemist has much to learn from the physicist in regard to the proper method of attacking such problems as these.

The electrochemist has been troubled in locating the source of electromotive force in cells. The physicist has similar difficulty in finding the origin of the contact potential between metals. Fundamentally it must be recognized that unless or until there are methods by which these quantities can be measured, questions involving them have no meaning.

A practical example of the meaninglessness of some questions involving electric potential has recently arisen in the numerous proposals that have been made to construct a speed indicator for aeroplanes which will give the speed with respect to the earth's surface independently of that of the wind surrounding the plane. It is reasoned that since the plane is moving through the earth's magnetic field a potential will be set up between the ends of a wire stretched between the wing's tips. It is only necessary to measure this potential difference in order to calculate the speed of the plane with respect to the earth. Careful analysis shows that the concept of the potential difference under these conditions is meaningless except with reference to a particular reference system. If this system is referred to the plane itself, this potential difference is zero, quite regardless of what the speed of the plane may be with reference to the earth. A contrary result would conflict with the relativity theory.

Meaningless questions will assume far greater importance in future years. We shall see that the latest forms of the quantum theory now give us the best of reasons for believing that the identity of separate electrons within atoms or molecules may be partly or wholly lost so that it may have no meaning to ask whether a particular electron we find as a result of experiment is the same electron which has previously produced an observed phenomenon. Even more far reaching in its consequences is the Bohr-Heisenberg uncertainty principle according to which it has no meaning to ask what is the precise position and velocity of an electron or atom. An electron may have a definite position or a definite velocity, but it can not in any exact sense have both. This doesn't mean merely that there are experimental difficulties in measuring them; it means that the concepts themselves (position and velocity) are relative to one another in a sense somewhat analogous to that of time and space in the relativity theory.

One's instinctive reaction when first questioned as to the objective reality of space, time, position, velocity, etc., is to object to such consideration on the grounds that they are too metaphysical. The recent advances in physics demonstrate that these methods of thinking are eminently practical; they represent, in fact, an attempt to get away from the metaphysical character of much of our thinking in the past. Instead of taking for granted objective realities corresponding to our concepts we now deal with things which can be measured in the laboratory, the concrete data that we have to start from.

It is, however, very useful to retain the concept of reality. Bridgman suggests that reality should be measured by the number of and the accuracy of the independent ways in which we arrive at similar measures of the concept in question. For example, owing to the fact that we have so many concordant methods of measuring the distance between the ends of a base line used for triangulation we attribute great reality to the concept of length, or rather, to those concepts of length which are applicable in cases of this kind. We thus have some justification for saying that two points are really one kilometer apart. We do not attribute, however, much reality to the concept of the diameter of an electron.

Thirty years ago the physical chemist doubted the existence of atoms or believed the concept was useless if not pernicious. A few years later the leader of this movement, Ostwald, in the preface of one of his books stated that he believed that the existence of atoms had been proved experimentally beyond question, although in previous books he had stated that there is always an infinite number of hypotheses that could be advanced to explain any given set of experimental facts.

To-day, what can we say in answer to the question "Does matter really consist of atoms?" Must we say that this is one of those meaningless questions? Of course, the amount of meaning that can be attached to any such question depends upon the definitions of the words and concepts which it contains. If we mean by atoms indivisible and indestructible, infinitely hard, elastic spheres, we are compelled to answer the question in the negative. In accordance with modern usage, however, we do not attribute any such properties to the atom. If, by the use of the word atom, we mean to imply principally the concept that matter consists of discrete particles which can be counted by the various methods which are now known for this purpose, we have the very best of reasons for answering the question in the affirmative. If in our studies of nature we discover evidences of discontinuities or of the presence of discrete natural units which can be correlated in a definite way with the numerical integers, we have come, it would seem, about as close to something absolute in nature as we can hope to get. Einstein in the relativity theory has taught us to look upon the intersection of world lines as the data upon which our observations of nature rest. Such points of introductions, which can be called events, are essentially discontinuities. In general, they are all

unlike one another. When we find in nature discrete units which in many respects appear to be identical with one another, and we can count these units, it would seem that the number of these units which we obtain as a result is apt to be independent of our system of reference, therefore they have in general a certain kind of absolute significance.

In this respect, therefore, it seems that the atomic theory and the quantum theory in which integers play such a fundamental rôle may be considered as representing reality to a higher degree than almost any other of our physical and chemical theories.

Skepticism in regard to an absolute meaning of words, concepts, models or mathematical theories should not prevent us from using all these abstractions in describing natural phenomena. The progress of physical chemistry was probably set back many years by the failure of the chemists to take full advantage of the atomic theory in describing the phenomena that they observed. The rejection of the atomic theory for this purpose was, I believe, based primarily upon a mistaken attempt to describe nature in some absolute manner. That is, it was thought that such concepts as energy, entropy, temperature, chemical potential, etc., represented something far more nearly absolute in character than the concept of atoms and molecules, so that nature should preferably be described in terms of the former rather than the latter. We must now recognize, however, that all these concepts are human inventions and have no absolute independent existence in nature. Our choice, therefore, can not lie between fact and hypothesis, but only between two concepts (or between two models) which enable us to give a better or worse description of natural phenomena. By better or worse we mean approximately: simpler or more complicated, more or less convenient, more or less general. If we compare Ostwald's attempts to teach chemistry without the use of the atomic theory with a good modern course based upon the atomic theory, we get an understanding of what should be meant by better or worse.

The more recent advances in atomic theory which have resulted from the development of the quantum theory and which have given us our present knowledge of atomic structure afford us interesting applications of the new methods of thought, first introduced into physics and chemistry by the relativity theory.

The older atomic and molecular theories of the chemists took on more definite form through the development of the kinetic theory of gases, and through the electron theory and the study of radioactivity developed to a point where the atom is conceived of as a nucleus consisting of a definite number of electrons revolving around the nucleus. The atom ceased to be indestructible and was no longer the smallest particle of matter which could take part in a chemical reaction. The nucleus, rather than the atom, became characteristic of the chemical elements. The chemical properties of the atom, however, depended upon the number and arrangement of electrons.

Bohr in 1913 developed a marvelous new theory of the atom by combining Planck's quantum theory with a relativity theory of the nuclear atom. He evolved several new quantitative mathematical relationships with new concepts such as energy levels, quantum states, etc., and showed how the spectra of elements could be explained in terms of these new concepts. He also gave a mechanical model consisting of electrons revolving in orbits about the nucleus according to laws which were partly classical and partly inconsistent with classical laws. This model enabled him to derive certain mathematical equations from which he was able to calculate the frequencies corresponding to the different lines in the spectra of hydrogen and other elements, these frequencies being obtained from fundamental quantities such as the charge and mass of the electron and the quantum constant h, and did not involve any quantities dependent on the properties of the elements in question. The agreement between the theory and experiment was practically perfect, often enabling the frequency to be calculated with an accuracy of one part in two hundred thousand.

Such remarkable success made most physicists and chemists believe that Bohr's model, for the hydrogen atom at least, was substantially correct. That is, they believed that Bohr's work proved that in a normal hydrogen atom the electron really described a circular orbit around a nucleus having a diameter and a frequency given by Bohr's model. Bohr himself never attached any such importance to the mechanical model, realizing that the important steps that he had taken consisted mainly in the introduction of new concepts and more particularly in the mathematical equations by which the observed frequencies in the spectral lines could be calculated.

Within recent years, largely through the work of Bohr himself and his students and Sommerfeld, Schroedinger and others, this theory of the hydrogen atom has undergone changes. According to Bohr's original model the radiation of energy corresponding to a spectral line resulted from a transition in which the electron passed from one stationary orbit to another. No physical picture of this transition seemed possible. To account for the known phenomena it seemed necessary that the transition should occur so rapidly that the electron would have to move from one orbit to another with a velocity greater than that of light, and yet the train of waves in the resulting radiation lasted for relatively long periods of time, about 10^{-8} second. Radiant energy could be ob-

sorbed by the atom only if the frequency was just that which was capable of transferring an electron from one orbit to another definite orbit. Thus, only one frequency could be obsorbed at a time by an atom. It was found, however, that the frequencies corresponding to many lines could be scattered by a single atom. This seemed to require the presence within any given atom of a number of oscillators as great as the number of lines in the spectrum. One of the greatest arguments in favor of the original Bohr theory was that it avoided just this sort of complication in the atom.

To get rid of difficulties such as these, Heisenberg and Born realized that it was necessary to sweep out of the theories of atomic structure the many concepts which were characteristic of the mechanical models that had been proposed and to develop a mathematical theory of the atom which would involve only concepts that were definable in terms of operations. That is, the theory was one that dealt more directly with measurable quantities such as the frequencies of spectral lines. New methods of matrix calculus had to be evolved, a kind of calculus of discontinuities or discrete quantities instead of the calculus of continuous quantities which had characterized classical mechanics.

Only a little later Schroedinger, by developing De Broglie's wave theory of quantum phenomena, was able to build up a theory that we will now refer to as the wave mechanics, according to which the whole atom with all its electrons can be looked upon as a wave phenomenon. The electrons are no longer considered to be moving in orbits. For example, the hydrogen atom is found to have spherical symmetry instead of the axial symmetry of the old Bohr model of the atom. Yet this theory leads to identically the same equations for the frequencies of the lines in the hydrogen spectrum. We must not say that Bohr's theory of the hydrogen atom has been overthrown. Bohr's *mechanical* model has been superseded, but the more important model which is represented by the equations and the concepts which he evolved is even better to-day than it was when it was first proposed.

The wave mechanics which involves the calculus of continuous variables is not now in conflict with the Born matrix calculus of discrete quantities. The two theories are essentially merely different mathematical methods applied to a single fundamental problem. The resulting mathematical equations always agree with one another. One begins to believe that the mathematical theory is a far better model of the atom than any of the mechanical models which are possible.

The long-standing conflict between the wave theory of light and the corpuscular quantum theory now disappears with the new wave mechanics, the two aspects of light being somewhat analogous to the two aspects of the quantum theory; the wave mechanics and the matrix mechanics. In fact, the quantum theory now indicates that the electron itself can be regarded as a particle or as a wave just as light can be thought of as a photon or a wave. Whatever remained of the conflict between the wave and corpuscular theory of light and the electron seems now to be fundamentally removed by the Bohr-Heisenberg uncertainty principle. To ask whether an electron is a particle or a wave is a meaningless question; the same is true of the question whether light consists of corpuscles or waves. One must answer that both of these are particles or waves according to the kind of operations that we may perform in observing them. If we make an experiment which proves that an electron has a very definite position then it would seem to prove that it is a particle. In that case, however, according to the uncertainty principle, we are not able to determine accurately the velocity and therefore can not predict where the particle will go.

Bohr has emphasized that the essential reason that the classical theory falls down in any detailed description of atomic phenomena is that our knowledge of such atomic systems can only be obtained through an act of observation which makes the observer inherently a part of the system. On the classical theory we assume that we could have knowledge of a completely closed system as though it were possible to know anything of what would go on in a strictly closed system. In order to make an observation some signal must be transmitted from the system to ourselves, and if we take this interaction completely into account we are forced to the quantum theory with its uncertainty principle.

An interesting feature of this new quantum mechanics is that the original conception of the relation between cause and effect which was universally accepted in science has lost its meaning. Atomic processes seem to be governed fundamentally by the law of probability. It has no meaning to ask when will a particular radium atom disintegrate, for no operation is conceivable by which such an event could be predicted. The same is true of every individual quantum process. We have no guarantee whatever that the expulsion of an α-particle from an atom of radium has any immediate cause. In chemistry the formation of nuclei in supercooled liquids, etc., must be essentially quantum phenomena in which no cause can be assigned for the formation of the individual nucleus. By varying the conditions we may alter the probability that a nucleus will appear at a given point, but in no absolute sense can we ever make a nucleus form through a direct cause.

By a deeper analysis of this question of causality Bohr concludes that we have an option of two alternative descriptions of natural phenomena. If we choose to describe phenomena in terms of ordinary

space and time then we must abandon causality. We may, however, retain the conception of causality if we are willing to describe atomic phenomena in terms of what the mathematician calls configuration space. Consider, for example, a helium atom with its two electrons. If we attempt to give the position of both of these electrons in space we would need a set of three coordinates, x, y, z, for each of the electrons; that is, six coordinates in all, three of which belong to one and three to the other electron. The mathematician, however, finds that the two electrons in general could also be described by one point in six-dimensional space, for such a point has six coordinates. This is a representation of two electrons as a single point in a configuration space of six dimensions. Now it turns out from Schroedinger's theory that the motion of electrons, or rather of the waves corresponding to them, can be completely described in the case of the helium atom by a quantity which has a particular value at each point in this six-dimensional space or configuration space. The helium atom, however, can be described in terms of the motion of two electrons in three-dimensional space if we are content merely to know the probabilities that the electrons may be found at any point in this space.

These matters undoubtedly seem very abstract to those of you who have not previously become familiar with them. I give them here mainly in order to illustrate how far the modern concepts of physics differ from those of twenty years ago.

If we must thus abandon our ordinary ideas of cause and effect, it may be asked why have the physicist and chemist so long believed that the whole teaching of science gave proof that every phenomenon resulted inevitably from the causes that led to it. I think the answer is that in the past scientists chose as the subjects for their investigations almost wholly those phenomena in which such definite relations as cause and effect could be found. These phenomena are those in which such enormous numbers of individual quantum phenomena are grouped together that the result is determined only by their averages. For example, when we study the variation of the pressure with the volume of a gas, the forces that we measure result from the impacts of great numbers of molecules, the average force remaining steady and definite. If, however, we had only one molecule in a small volume the pressure exerted on the walls would be zero except for those instants at which the molecule struck the wall. It would then be impossible to predict in advance what the pressure would be at a particular time.

I think that in trying to estimate the reliability of any of our scientific knowledge we should keep in mind that the whole complexion of a science may be made to change by the psychology of the investigators which governs the choice of the subjects that are investigated.

Our best knowledge of time and its relation to other concepts is that which we have obtained through Einstein. Yet in the whole relativity theory there is nothing to distinguish between positive and negative time, that is, between future and past, any more than there is between different directions in space, such as right and left. There thus appears to be something curiously incomplete in our knowledge of time, for every one of us knows the vast practical difference between past and future. Eddington in his recent book, "The Nature of the Physical World," discusses the "arrow of time" at some length. He suggests that the second law of thermodynamics is the only fundamental law of nature which provides us with any distinction between future and past. One way of stating this law is that all spontaneous processes that occur in nature involve an increase in entropy. Eddington thus proposes that the positive direction of time can be defined as that direction in which the entropy increases. If we had a system in absolute equilibrium the entropy would be constant, and there would then be no arrow of time. This is in accord with the fact that in such a system there are no changes with time.

It is improbable that there are two independent fundamental factors which provide an arrow for time, so that it would seem that Eddington in having found one such factor has found the only one. There are, however, grave difficulties with this view. An arrow is a vector quantity which should have magnitude as well as direction. Now the rate of change of entropy does not seem to give us any measure of time. For this purpose we use phenomena which are as nearly reversible as possible, such as the swinging of a pendulum in vacuum.

Fundamentally, entropy is a measure of randomness. A random distribution of molecules in space and velocity is a system having the maximum entropy. If we throw a pack of cards out of the window and collect them from the ground they have become effectively shuffled. We would not expect by this process starting with a shuffled pack of cards to find them at the end in the order in which they came from the manufacturer. The direction in which the randomness increases thus provides an arrow for time. This arrow is, however, equivalent to that involving the increase of entropy.

It is still an open question, however, whether processes directed by intelligent beings may not involve a decrease in entropy. In fact, it seems conceivable that the evolution of organic life on the earth is in some measure fundamentally contrary to the second law of thermodynamics. The inherent tendency of evolution seems to be to bring about an ordered

rather than a random arrangement of parts, and in the future, perhaps, forms of life may evolve which cause a decrease of entropy on a large scale. Are we then to have some parts of the universe in which the arrow of time points in the opposite direction from that in neighboring parts?

Such speculations may seem fantastic. It is, however, I believe, of the utmost importance for the chemists and the physicists to evolve fundamentally sound conceptions of such things as time and entropy.

The profound changes in physical thought, particularly those represented by the quantum theory, are rapidly bringing about a revolution in physical chemistry. The third law of thermodynamics involving chemical constants has changed radically our methods of studying chemical equilibria. The application of the quantum theory to band spectra promises to be of the utmost importance in chemistry. By enabling us to determine the moments of inertia of chemical molecules, the actual distances between the nuclei of the atoms in molecules can be found. Apparently our most accurate determinations of the heats of dissociation of elementary gases can be obtained from the band spectra through a knowledge of the energy levels of the various possible states of the molecules. In recent numbers of the *Journal* of the American Chemical Society, particularly in the paper of Giauque and Johnston, we see the beginnings of what promises to be the most accurate and fertile source of knowledge of chemical equilibria. From a detailed knowledge of the spectrum, for example of oxygen, and without recourse to any other experimental determinations, the specific heat at all temperatures can be calculated, and the entropy of oxygen at all temperatures is thus found. This, together with the heats of reactions which may be found by a similar method, makes possible the calculation of the degree of dissociation of oxygen and will ultimately make possible the calculation of all chemical equilibria.

The remarkable work of Dennison, Bonhoeffer and Eucken in predicting and isolating parahydrogen should prove to the chemist how many of his chemical discoveries will be obtained in the future by the application of these new theories of physics.

Gurney and Condon have recently derived from the wave mechanics an explanation of the fundamental laws of radioactivity. Similar methods will probably before long enable us to understand the processes involved in chemical reactions far better than they ever have before.

Physics and chemistry are being inevitably drawn closer together. It seems that there has never been a time when we can predict with such certainty rapid progress in fundamental chemistry, for the new theories of physics have as yet scarcely begun to be applied in the field of chemistry. The physicist, on the other hand, has much to learn from an increased knowledge of chemical phenomena which should provide him with a richness of experimental data far greater than any he has yet had an opportunity to use.

Unfortunately, although theoretical physics and chemistry are thus supplementing each other in many respects, are being merged into a new science, there are remarkably few men as yet that have received adequate training in both sciences. Before long, I hope, sharp distinctions between physics and chemistry will no longer exist, but at present there seems to be a very practical distinction.

In order to find approximately how many chemists are also active as physicists, and *vice versa,* I have selected at random 100 pages of the fourth edition of "American Men of Science" (1927), which contains the names of 13,500 American scientists. Of these, approximately 2,700 are classed as chemists and 760 as physicists. Of the chemists 87 per cent. are members of the American Chemical Society, while only 2.5 per cent. belong also to the American Physical Society. Seventy-seven per cent. of the physicists are members of the American Physical Society, while 4.3 per cent. are also members of the American Chemical Society. Thus only about 3 per cent. of the physicists and chemists of the United States whose names are given in the "American Men of Science" belong to both of the national societies. This leaves far too small a number of men who are capable or are properly prepared to carry on the important work of bringing these two sciences closer together.

To pave the way for the coming revolutionary changes in chemistry we must be prepared to modify our methods of thinking, probably along lines now so prevalent in physics. But, above all, we must urge young chemists in the universities and after graduation to become thoroughly well trained in mathematics and in modern physics.

THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

THE MICHAEL P. RICH BEQUEST FOR THE ADVANCEMENT OF SCIENCE

THE general endowment of the American Association for the Advancement of Science has been increased by a bequest of $10,000 through the will of the late Dr. Michael P. Rich, of New York City, who died on April 12, 1929. Dr. Rich had been a member of the association since 1891, enrolled in

Section N (Medical Sciences). In his last will and testament he wrote, "I give and bequeath to the American Association for the Advancement of Science, a Massachusetts corporation, the sum of ten thousand dollars, to be added to and become a part of its endowment fund."

As many know, the American Association has an endowment fund, now amounting to over $150,000, which is kept permanently invested by the treasurer of the association, who is now Mr. John L. Wirt, of the Carnegie Institution of Washington. It is administered under the laws of the Commonwealth of Massachusetts, from which the association received its incorporation in 1875. The income from this fund, at the present average annual rate of about 4.7 per cent., is available for appropriation by the association council, in accordance with constitutional provisions and those of the donors. The association has been the recipient of a number of larger gifts and bequests and of many smaller ones and the permanent endowment has been increased each year since it was inaugurated. To the endowment are added each year all sustaining membership fees (of $1,000) and all life-membership fees (of $100). Gifts have been received also for the current funds of the association.

The uses for which the council may appropriate the income from the endowment may be classified as (1) for scientific research, (2) for the general purposes of the advancement of science and (3) for special purposes. It is provided that the income from the fees paid by life members and sustaining members shall be available for general purposes until the decease of these members, after which it shall become available for furthering scientific research. For the association year 1927–28 (October 1, 1927, to September 30, 1928) the income from the fees of living life members and sustaining members was $1,341.85 and the income from the fees of deceased endowment members was $560.95. The total endowment income for 1927–28 was $6,493.48, available as follows:

For research	$4,327.69
For general purposes	1,956.46
For special purposes	209.33
	$6,493.48

Grants in aid of research, to individuals and to organizations, are regularly made from the first part of the income. From the second part of the income are paid the annual journal subscriptions for all living life members and sustaining members, who receive the official journal throughout life. The income from the Jane M. Smith Fund is used, according to the terms of that bequest, specifically for the establishment of emeritus life memberships, of which two or three have been created annually in recent years. The council elects these emeritus life members from among the annual members of longest standing. The treasurer's report on the endowment funds of the association appears annually in SCIENCE about February 1.

It is seen that the Michael P. Rich bequest constitutes a very definite addition to the association's endowment. It is a lasting memorial to the active interest taken by Dr. Rich in the general aims of the association. With the rapidly increasing membership, which now amounts to over 18,500, and with the recently greatly enhanced appreciation of the association by the intelligent public of the United States, such additions should be not infrequent in the future. The association welcomes gifts and bequests for the advancement of science and undertakes to administer such funds in accordance with the wishes of the donors.

BURTON E. LIVINGSTON,
Permanent Secretary

APPLICATIONS FOR GRANTS FOR 1930

THE council of the American Association for the Advancement of Science makes available each year a sum of about three thousand dollars from the income of the permanently invested endowment funds and this appropriation is allotted to individual members as grants in aid of research. Allotments are made by the Committee on Grants for Research, at the time of the annual meeting of the association, and all applicants are informed in January with regard to the outcome. Each year the list of grantees for the ensuing year appears in SCIENCE about February 1. Grants become available immediately, the funds being disbursed by the treasurer of the association in accordance with the desires of the grantees.

Applications for grants are made on special blanks, obtainable from the permanent secretary's office in Washington. For the year 1930 all applications must be received before December 1, 1929. Consideration is given to applications for any amount up to five hundred dollars; while a few grants of that amount have been allotted in recent years, most of the grants have been for smaller sums. Each application is to be supported by letters from two persons acquainted with the applicant and with the project for which the grant is requested.

The Committee on Grants for Research has the following membership. The number given in parenthesis after each name denotes the last calendar year of the member's term of office.

L. G. Hoxton, for physics (*chairman*); University of Virginia, Charlottesville, Virginia (1929).

Vernon Kellogg, for zoology; National Research Council, Washington, D. C. (1929).

W. Lash Miller, for chemistry; University of Toronto, Toronto, Canada (1930).

Oswald Veblen, for mathematics; Princeton University, Princeton, New Jersey (1930).

Walter S. Adams, for astronomy; Mount Wilson Observatory, Pasadena, California (1931).

Karl F. Kellerman, for botany; Bureau of Plant Industry, U. S. Department of Agriculture, Washington, D. C. (1931).

Charles P. Berkey, for geology; Columbia University, New York, New York (1932).

William Charles White, for medicine; Hygienic Laboratory, U. S. Public Health Service, 25th and E Sts. N. W., Washington, D. C. (1932).

THE SECTION OF GEOLOGY AND GEOGRAPHY AT DES MOINES

SECTION E will hold sessions for the reading of papers on Monday and Tuesday, December 30 and 31. The address of the retiring vice-president of the section, Professor Frank Leverett, entitled "Problems of the Upper Ohio Drainage," will be given at 4 P. M. on Monday. There will be a dinner for geologists and geographers on either Monday or Tuesday evening. A public lecture by Dr. George F. Kay on the Pleistocene geology of Iowa and adjacent states will be presented at a general session of the entire association scheduled to occur on Tuesday, probably at 4:30 P. M. Hotel headquarters will be the Brown Hotel, Fourth and Chestnut Streets, and the sessions of this section will be held in the auditorium of the Y. M. C. A. immediately across the street from this hotel. Rooms with bath range upward from $2 for single rooms and $3 for double rooms. Reservations for hotel accommodations should be made early by members and directly with the hotel, not through secretaries or local committees.

Des Moines is at the center of the classic area for the study of the glacial deposits of the Mississippi Valley and it is expected that several papers dealing with Pleistocene problems will be presented. Other papers will consider the stratigraphy of the Mississippi Valley and still others will deal with general geological problems. A large attendance of geologists from the midwest is assured.

Members of Section E who desire to present papers should send the exact title and an abstract of not more than 250 words to reach the secretary not later than November 25; titles received later than this can not be placed on the program and titles without abstracts will not be considered or accepted. The group (economic geology, general geology, stratigraphy, Pleistocene geology, physiography, geography, etc.) in which the paper is to be read and whether charts or lantern slides will be used should be indicated.

KIRTLEY F. MATHER,
Secretary of Section E

GEOLOGICAL MUSEUM,
HARVARD UNIVERSITY

PSYCHOLOGY

Section I (Psychology) of the American Association for the Advancement of Science will hold its sessions on Friday, December 27, and Saturday, December 28, at Des Moines at a place to be designated later. In view of the fact that there is to be no meeting of the American Psychological Association this year, this meeting furnishes an excellent opportunity for the presentation of papers. All fellows and members of the section who wish to read papers should submit the title of their paper with an estimate of the time required up to a limit of twenty minutes to the secretary of the section, Dr. John E. Anderson, Institute of Child Welfare, University of Minnesota, *not later* than Saturday, November 23. Notice will be given of the acceptance of titles.

SCIENTIFIC EVENTS

THE OBSERVATORY OF THE UNIVERSITY OF LONDON

WE learn from the London *Times* that the new observatory, erected by the University of London at Mill Hill, was opened by Sir Frank Dyson, the astronomer royal, on October 8. The need for such an observatory, sufficiently and adequately equipped for research work, is said to have been felt by the university for some years. It became known a short time ago that Mr. J. G. Wilson was possessed of a 24-inch reflecting telescope, which had been constructed for his father, Mr. W. E. Wilson, F.R.S., of which he wished to dispose. The instrument at that time was erected at Mr. Wilson's home at Darramona, West Meath, Ireland, and he generously offered it to the university, provided that a suitable building was erected for it. After prolonged negotiations and the consideration of many sites, an arrangement was come to with the Hendon Urban Council for the granting of a site on the west of the Watford by-pass road, opposite Mill Hill Park. The Hendon Council, with the sanction of the Ministry of Health, have leased to the university the site, for a period of 999 years, at a nominal rental, the senate of the university granted a sum of £5,000 towards the erection and maintenance of a suitable building, and University College, King's College, Bedford College, East London College and the London School of Economics agreed to vote annual subsidies for a period of years towards maintenance expenses.

In August, 1928, the Wilson telescope was moved to the workshop of the Department of Applied Mathe-

matics and assembled there. The breech piece required considerable modification, and an electric motor for rewinding the driving clock automatically was added. This motor was supplied by Messrs. Tyler and Freeman, who contracted for the electric light, heating and power in the university observatory, and assistance was given with regard to this item by the departments of mechanical and electrical engineering at the college.

The 18-foot dome was constructed by Messrs. Cooke, Troughton and Simms, Limited. At Mr. Gregory's suggestion Messrs. Cooke altered the design of their standard dome, in order to make it possible to rotate the dome by means of an electric motor, fixed to the wall of the observatory. This is effected by means of a friction drive operating upon a ring mounted on the dome and revolving with it. The dome was designed to rotate in either sense at the rate of a quarter revolution per minute and to be controlled from two points, one on the floor and one at the eye-end of the instrument. In order to obviate the difficulties consequent upon the employment, for the distant controls, of a long and heavy trailing cable carrying an electric current at 4.5 volts, a new form of polarized relay was designed by Mr. Gregory and Mr. Norman Whittle, so as to enable the 3-phase alternating current dome motor to be controlled safely from either end of the telescope by means of two small switches, which operate the relay by severing a single low-voltage circuit. This relay was made in the workshop and installed early in June last, and so far has been found to work in a very reliable manner.

The observatory is provided with a spectrographic laboratory, the principal instruments being a 10-foot Rowland grating spectrograph and a spring-driven coelostat. The latter is mounted on the roof immediately over the laboratory under a copper dome, which may be completely removed by means of a davit and winding mechanism operated in the laboratory. A new form of universal mounting has been designed by Mr. Gregory, in collaboration with Professor Filon, and executed by Messrs. G. Wailes and Co., with which the coelostat may be moved into its required position for any star by means of a single setting on a divided circle, and then, when the hour circle of the coelostat has been set and the driving mechanism started, light from the star may be focused on the slit of a fixed spectrograph by means of a 7-inch object glass of 12-foot focal length which is incorporated in the instrument.

The general public will be permitted to view the observatory between 2:30 and 4:30 P.M., on two days in the months of October, November, December, January, February, March, May and June. Parties viewing must not exceed 12 in number at any one time. The director of the observatory is Professor L. N. G. Filon, and the Wilson observer is Mr. C. C. L. Gregory.

THE MEDICAL CENTER IN BOSTON

A NEW ENGLAND MEDICAL CENTER, which when completed will consist of a city dispensary, a modern free hospital for babies, classrooms and clinical teaching facilities for training physicians and a scientific laboratory and operating equipment for the use of all three, will be contained in a group of buildings to be erected at the present location of the Boston Dispensary on Bennet Street, South End, near the Park Square district.

Announcement of this new group of medical forces, organized to train family physicians for the smaller communities of New England and to provide more adequate relief for the needy sick, was made public on October 10 following a luncheon at the Chamber of Commerce attended by trustees of the Boston Dispensary, the Boston Floating Hospital and Tufts College, the three institutions behind the project.

Plans already made call for the remodeling and enlargement of the dispensary, the erection of a forty-bed land hospital of the Floating Hospital and a third building will be constructed jointly to provide a center of clinical training for the Tufts College Medical School, additional clinics for the dispensary and a dormitory for nurses.

While the three institutions will continue to maintain their separate identities, they will, in combining, benefit by the economy and efficiency resulting from a merging of interests. Laboratories, operating rooms, X-ray plant, dining-rooms, kitchen, laundry, power plant and pharmacy will be shared in common.

It is estimated that the carrying out of this building project will cost $970,000. To operate the completed medical center will require the addition of at least $520,000 to the endowment funds of the three institutions, making necessary a total outlay of $1,500,000, in addition to the present resources of the Boston Dispensary, the Floating Hospital and Tufts College Medical School.

One of the principal motives behind the consolidation is that of bringing back to a position of greater importance the family practitioner and the ideals which he represents.

A statement issued by the Administrative Board says:

> The formation of the New England Medical Center will mark the crystallization of a new and significant trend in medicine. During the last fifty years the trend has been entirely in the direction of the scientific control of disease, and has resulted in the development of great hos-

pitals, great laboratories and great teaching centers. It has been a period of unprecedented progress and immeasurable benefits. Yet, during this period, a serious and widening gap has appeared in the medical structure. Modern, scientific medicine has acted as a magnet to draw the great majority of doctors into the large centers as specialists, laboratory research men and teachers. Fewer and fewer men have gone out into the smaller communities of New England to become practicing physicians. The old family doctor—the backbone of the medical profession—is gradually dying out.

Thus, while medicine has developed to a greater perfection than ever, its development has been unbalanced. We have enough doctors in the large cities, but far too few in the rural districts. We have superlative medical resources, but they are not accessible to a large proportion of the people.

The New England Medical Center, through its program of bringing back the family physician and injecting the ideals of the family physician into its treatment of the sick, will help restore a much needed balance.

MEDICAL FELLOWSHIPS OF THE NATIONAL RESEARCH COUNCIL

THE Medical Fellowship Board of the National Research Council, of which Dr. G. Carl Huber, professor of anatomy and dean of the graduate school of the University of Michigan, is the chairman, met on September 21 and made the following appointments for the year 1929–1930:

Edwin Marshall Deery, neurology.
Ade T. Milhorat, physiology.
Sydney L. Wright, Jr., physical chemistry (reappointment).

The following fellows, appointed at the April meeting of the board, have taken up their fellowship work:

Edgar V. Allen, internal medicine.
Eric G. Ball, physiological chemistry.
Claude E. Forkner, pathology and clinical investigation.
Emidio L. Gaspari, bacteriology and immunology.
Arthur K. Koff, obstetrics.
Milton Levy, biochemistry.
Ava J. McAmis, physiological chemistry.
Leone McGregor, pathology.
Charles Midlo, anatomy.
Bruce Webster, internal medicine.

Those whose terms of fellowship expired during the summer have received the following appointments:

Leon H. Collins, Jr., department of pharmacology, University of Pennsylvania.
Arda A. Green, research fellow in physical chemistry, Harvard Medical School, and tutor in biochemical sciences and in biology, Radcliffe College.
Robert M. Moore, Barnes Hospital, St. Louis, Missouri.
Herbert L. Ratcliffe, assistant pathologist to the Zoological Society of Philadelphia and instructor in pathology, University of Pennsylvania School of Medicine.
Francis O. Schmitt, assistant professor of zoology, Washington University, St. Louis.
Richard Thompson, with the Milbank Fund (Columbia University) for the study of infantile paralysis.
Vincent du Vigneaud, associate in the department of physiological chemistry, University of Illinois.
C. Eugene Woodruff, on Dr. Goodpasture's staff, Vanderbilt University.

ADDRESS TO PRESIDENT CAMPBELL BY THE ACADEMIC SENATE OF THE UNIVERSITY OF CALIFORNIA

AT the close of the Commencement Day exercises last May, Dr. William Wallace Campbell, president of the University of California and director of the Lick Observatory, announced that he purposes to retire from the active service of the university thirteen months later (July 1, 1930), at the close of the semester in which he expects to reach the age of sixty-eight years, the age of automatic retirement in accordance with the specifications of the University's Pension System.

The academic senate of the University of California, at the stated meeting of October 7, unanimously and by a rising vote tendered the following address to President Campbell:

It is with profound regret that the Academic Senate has learned of your approaching retirement from the presidency.

The extraordinary genius for organization previously demonstrated in the development of the Lick Observatory, in many eclipse expeditions, and in bringing about international cooperation among astronomers has made your present office a model of business efficiency. Every problem presented by a university department has been answered promptly and without ambiguity.

You have surrounded yourself with an unusual group of wise councilors and able executives in whose judgment the faculty has had confidence.

In the midst of complex external problems and great material development, your administration has not been diverted from the main purpose of a university, the advancement of teaching and of learning. The departments have been strengthened by the addition of men of distinction and by increased facilities for productive scholarship.

Your administration has been a period of tranquillity and healthy growth such as few universities have enjoyed, and we, the Academic Senate, desire to express to you our heartfelt appreciation.

SCIENTIFIC NOTES AND NEWS

THE jubilee celebration in honor of Mr. Edison culminated on October 21 when the Edison School of Technology was dedicated at Dearborn with addresses by Mr. Hoover, Mr. Ford, Mr. Young and Mr. Edison. The addresses, including one from Professor Einstein in Berlin, were broadcast over the world.

MR. HOOVER will make an address on October 30 when Mme. Curie will be presented with a gram of radium at the Academy of Sciences building in Washington. Mme. Curie will be a guest of Mr. and Mrs. Hoover at the White House on October 29 and 30.

DR. EDWIN E. SLOSSON, director of Science Service, formerly professor of chemistry in the University of Wyoming, and later literary editor of the *Independent*, died in Washington on October 15, in his sixty-fifth year.

AT the annual meeting of the American Electrochemical Society, which opened in Pittsburgh on September 21, the medal of the society was awarded to Edward Goodrich Acheson for his basic inventions.

PROFESSOR JAMES HENRY BREASTED, director of the Oriental Institute of the University of Chicago, was awarded the gold medal of the Geographic Society of Chicago on October 8 "for eminent achievement in recovering the lost civilization of the ancient Near East." On this occasion Professor Breasted made an address on recent researches by expeditions now in Egypt, Palestine, Assyria and the Hittite country, and their bearing on the growth of modern civilization.

THE Manly medal for achievement in aeronautical engineering for 1928 has been awarded to Samuel D. Heron, power plant engineer of the material division of the air corps at Wright Field, Dayton, Ohio. The medal is bestowed upon the person considered to have made the most important contribution during the year to aeronautical engine development. The award is named in honor of Charles M. Manly, chief engineer for Samuel P. Langley in the design and building of his radial engine for the early Langley monoplane.

PROFESSOR EDWIN B. WILSON, of Harvard University, has been elected to the presidency for 1929–30 of the Social Science Research Council with offices at 230 Park Avenue, New York. Dr. Wilson has been granted a leave of absence for one year from his professorship of vital statistics in the Harvard Medical School.

AT the annual meeting of Delta Omega, the honorary public health society, held in Minneapolis on October 2, during the convention of the American Public Health Association, Dr. C. C. Young, director of the bureau of laboratories of the Michigan State Department of Health, was elected national president; Dr. John A. Ferrell, of the Rockefeller Foundation in New York, was elected national vice-president, and Dr. James A. Tobey, of New York, was reelected national secretary-treasurer.

DR. HARRY C. OBERHOLSER, of the Bureau of Biological Survey, was honored by a dinner given on October 9 at San Antonio, Texas, by the Izaak Walton League and the Academy of Science. These organizations took advantage of his visit to show their appreciation for his leadership in the wild-life conservation of the survey and especially for what he has done in preserving a record of Texas birds.

THE nominating committee of the American College of Surgeons has nominated the following as new members of the board of governors: Dr. Edward J. Ill, of Newark, N. J.; Dr. Burton J. Lee, of New York; Dr. Southgate Leigh, of Norfolk, and Dr. Arthur M. Shipley, of Baltimore.

THE University of Virginia announces the opening of a laboratory where a series of investigations in the chemistry of alkaloids and related substances will be carried on under the auspices of the division of medical sciences of the National Research Council. Dr. Lyndon F. Small, research associate at the university, has been appointed director of the new laboratory. The present personnel includes Professor Erich Mosettig, Vienna; Dr. Alfred Burger, Vienna; Dr. Frank L. Cohen, Northwestern University; Mr. Jakob van de Kamp, Utrecht, and Mr. Louis Eilers, Illinois.

DR. HARRY C. KREMERS has resigned his position as assistant professor in the University of Illinois and is now employed by Röhm and Haas as inorganic chemist in their Chas. Lennig Company plant at Bridesburg, Philadelphia, Pa.

W. V. BALDUP, assistant professor of entomology in the University of Illinois, has a year's leave of absence and is at present in Washington to complete a revisional study of the chalcid genus *Decatoma* as found in America north of Mexico, after which most of the year will be devoted to a study of the bionomic and economic literature dealing with entomophagous insects.

H. G. DEMING has taken up his work as professor of chemistry at the University of Nebraska after having spent a year with Arthur D. Little, Inc., at Cambridge, Massachusetts.

DR. PAUL S. MARTIN, of Chicago, as a member of the staff of the department of anthropology at the

Field Museum of Natural History, is now at the museum, where he has assumed his work as assistant curator in charge of North American archeology. His first work will be a revision of the museum's collections representing the archeology of North American Indian tribes, a project that will require a long period for completion.

C. C. LAMB, assistant curator of mammals at the University of California Museum of Vertebrate Zoology, has returned to Berkeley, after spending a year in Lower California, where he collected 2,700 specimens of mammals, birds and reptiles.

DR. F. W. ZERBAN, of the New York Sugar Trade Laboratory, Inc., has returned from his trip to Java, where he attended the third congress of the International Society of Sugar Trade Technologists, held at Sourabaya. Dr. Zerban has been elected president of the society for the next three-year term. The fourth congress is to be held at San Juan, Porto Rico, in the spring of 1932.

FREDERICK G. CLAPP, consulting geologist and petroleum engineer, of New York and Paris, was a delegate of the United States government, the National Research Council and the National Academy of Sciences to the Second International Drilling Congress which met in Paris, Nancy, Strasbourg and Pechelbronn from September 15 to 23. The program of the congress included a number of papers on oil, drilling, geology and geophysics, and the oil wells and mines at Pechelbronn and vicinity were visited.

HENRY ARNSTEIN sailed on September 21 for Brazil, Argentina and Chile, to deliver a series of lectures on "The Development of Natural Resources," "The Elimination of Waste" and "The Recovery of By-products." While in South America he plans to start the operation of several alcoholic motor-fuel plants recently completed there.

PROFESSOR FRANZ KOELSCH, of the University of Munich, an authority on industrial diseases and labor conditions, has been visiting the United States during the present month, under the direction of Dr. Frederick L. Hoffman. Dr. Koelsch has been inspecting industrial establishments as far west as Chicago.

DR. E. V. COWDRY, professor of cytology at Washington University School of Medicine, delivered a lecture on "Recent Advances in our Knowledge of Yellow Fever" on October 8 under the joint auspices of Sigma Xi and the school of medicine at the University of Missouri.

THE Harvard Engineering Society held a meeting to commemorate the fiftieth anniversary of the incandescent lamp on October 18. Professor A. E. Kennelly, who was principal electrical assistant to Mr. Edison from 1887 to 1894, gave the address.

THE Institute of Medicine of Chicago and the Society of Internal Medicine of Chicago will be addressed on October 25, at the City Club, by Dr. Walter B. Cannon, George Higginson professor of physiology, Harvard University Medical School, on "Function of the Sympathetic System in Maintaining the Stability of the Organism."

PROFESSOR GEORGE V. VOLBORTH, for many years assistant to Professor Pavlov, and Professor Z. A. Orbeli, professor of physiology in the Medical Institute, Leningrad, Russia, lectured at the Mayo Foundation, Rochester, on September 26 and 27 on "Conditioned Reflexes" and "Studies on the Function of the Sympathetic System."

DR. DAVID P. D. WILKIE, professor of surgery in Edinburgh University, is visiting this country for three weeks. During his stay he will give the Murphy oration before the American College of Surgeons. He will also act as chief surgeon *pro tempore* at the Peter Bent Brigham Hospital, Boston, *vice* Dr. Harvey Cushing, and later as director of surgery *pro tempore* at the Lakeside Hospital, Cleveland, *vice* Dr. Elliott C. Cutler.

PROFESSOR OTTO WARBURG, of the Kaiser Wilhelm Institute, Berlin, will give the nineteenth course of lectures of the Herter Foundation, beginning on October 19, on "The Enzyme Problem and Biologic Oxidations."

PROFESSOR J. ARTHUR THOMSON, of Aberdeen, will lecture at the University of Buffalo on April 11, 1930, under the auspices of the Fenton Foundation. Professor Thomson's subject will be "Different Kinds of Evolution."

DR. HARRY GIDEON WELLS, professor and chairman of the department of pathology of the University of Chicago, will give the tenth Pasteur lecture before the Chicago Institute of Medicine on November 22 on "Immunology, Biochemistry and Evolution."

THE school of chemistry and physics, in cooperation with the ceramics department of the school of mines and metallurgy of the Pennsylvania State College, announces the fourth annual Priestley lectures to be given by Dr. Louis Navias, research ceramist of the General Electric Company. These lectures will be held the evenings of December 16, 17, 18, 19 and 20. The five lectures will be grouped about the general topic "The Relation of Physical Chemistry to Ceramics."

THE *Journal* of the American Medical Association states that a commemorative plaque placed on the natal home of Edme-Hippolyte Marié-Davy, physi-

cist-meteorologist and former director of the Montsouris Observatory, was recently dedicated at Clamecy.

THE Texas Academy of Science will hold its annual meeting from November 29 to 30 at College Station, Texas. A large attendance is expected, because of the importance of this meeting. The new constitution will be formally adopted.

THE geologic excursion of the Virginia Polytechnic Institute for the summer quarter of 1929 was held from June 22 to August 22; seventeen students representing eight colleges, with R. J. Holden, professor of geology at the Virginia Polytechnic Institute, as instructor, traveled by automobile northwestward from Blacksburg, Virginia, to St. Paul, westward to the Pacific Coast, southward to Mexico, thence along the southern border states and northeastward to Blacksburg, covering a distance of 10,000 miles. Points of special geologic interest were visited, but the chief purpose of the excursion was to observe field illustrations of a wide variety of phenomena in physiographic, glacial, structural, stratigraphic and historical geology.

MRS. JOSEPH W. WORK, of Evanston, Ill., has presented a collection of both cut and mounted gems to Field Museum of Natural History. The collection, which will be used in the museum's department of geology, includes blue pearl, Mexican opals, Australian opals, black opals, Honduras pink opals, rhodolites, kunzite, hair stone, star sapphires, Chinese jades and other stones.

THE *Journal of Industrial and Engineering Chemistry* announces that the Maltbie Chemical Company, of Newark, N. J., has contributed a grant for a research fellowship for the coming year to the Philadelphia College of Pharmacy and Science. The research work to be done under this fellowship will be fundamental in character and will cover a study of the toxicity, pharmacology and bactericidal efficiency of creosote, creosote compounds and constituents of creosote. The work to be done under this fellowship follows the chemical researches on creosote of the past year under the Maltbie Chemical Company fellowship at Princeton University.

RECENTLY Dr. Alice Kibbe, professor of biology in Carthage College, received a number of rare specimens from the collections belonging to the late Dr. Samuel B. Mead, who for many years was a physician and botanist at Augusta, Illinois. The collection consists of three scrapbooks, many rare scientific works, and scientific apparatus. The scientific equipment includes a primitive type of microscope, two separate sets of balances for weighing drugs and minerals, mortar pestle, mechanical drawing sets, a series of section razors of unique pattern, copies of meteorological records furnished to the United States government from 1826 to 1880, the year of the death of Dr. Mead. There are also framed specimens of two species of plants, discovered by Dr. Mead, and named Mead's sedge and Mead's milkweed, in honor of him, by Drs. Torrey and Bailey. These specimens are held in trust by Carthage College for Dr. Mead's heirs.

A SUBCOMMITTEE was appointed by the British Committee of Civil Research last April to consider and report on means for the mass destruction of "the Desert Locust *Schistocerca gregaria* Forsk," and on methods for ascertaining the reasons for the periodic swarming of this species with a view to its control. The committee draws attention to the heavy losses caused by locust plagues, partly by the destruction of crops, with consequent fall in production and curtailment of exports, and partly by the necessity of special expenditure on locust control and relief measures, which in Kenya had already amounted to £50,000 in May, 1929, as a result of the locust invasion which began on a large scale in 1928. It is, however, pointed out that less is known about locusts than about many noxious insects of less economic importance, a fact due to the periodic nature of the swarming of locusts and the false sense of security engendered in the intervening periods. The committee therefore recommends that a unified research scheme should be arranged from which all the affected territories would benefit, and to the cost of which each would contribute a share. The draft scheme of research, which it is recommended should be submitted to the governments of Kenya, Uganda, Tanganyika Territory, British Somaliland, Nigeria, Sierra Leone, the Gold Coast, Palestine, Transjordan and Iraq, the Sudan and India, covers methods of control, the location of possible permanent breeding areas and migration routes, and the bionomics of the locust and the periodicity of its outbreaks. It is hoped that the Royal Air Force may be able to cooperate in the work of reconnaissance, and perhaps in the destruction of locusts. The cost of the scheme is estimated at about £4,000 a year for five years.

THE multiple industrial fellowship on Portland cement of the Mellon Institute of Industrial Research and the Eastern Face Brick Manufacturers' Association have recently inaugurated a broad scientific study of the problems of bricklaying. So many factors are involved in the construction of a brick wall that it is necessary to limit the investigation to combinations of variables most likely to occur in actual practice. The project has been under discussion for a considerable period of time; experiments were begun by Dr. F. O. Anderegg, senior industrial fellow at Mellon In-

stitute, and his assistants only after a satisfactory program had been worked out. At the present time over 300 experimental brick walls or panels have been erected in order to find the most suitable combinations of materials and workmanship. The following problems are being investigated: the rate of absorption and total absorption of moisture by brick; the surface characters of brick; the merits of different cementing materials, ranging from pure lime to pure cement, and of various sands and mortar pigments; the effect of varying the type of backing, both as to material and size of unit; the results of variation in workmanship, including pointing, tapping and the filling of head-joints; the effect of variation in design, involving a study of coping and parapet construction, of capillary contact, of condensation and of elasticity, and the behavior of mortar with reference to the other variables in all types of climatic conditions. All results of these studies will be published for the benefit of every one interested in building construction.

THE report of the Bureau of Science of the Philippine Islands for 1927 has just been issued. We learn from it that the *Philippine Journal of Science,* embodying the results of the research work of the bureau, was issued during that year in three volumes with an aggregate of 1,511 pages, 157 plates and 111 text figures. According to the report the *Journal* is sent to 919 paid subscribers and exchanges, while 109 copies are distributed free for review to associate editors and to others. The total mailing list is 1,028. This is distributed as follows: Philippines, 94; remainder of Asia, 185; Europe, 293; North America, 359; South America, 25; Africa, 29; Australia and neighboring islands, 43. These figures show that the journal is widely distributed to scientific institutions in all parts of the world. Two monographs were issued during the year, three were in proof and one was being prepared for the printer. The biennial publication on the mineral resources was issued for the years 1924–1925. This publication took the form of a twenty-fifth anniversary number and contains a summary of Philippine geology and mineral resources. Two popular bulletins, one press bulletin and an annual report were also issued during the year. The library continued to grow in size and usefulness and has maintained its high standard of excellence. During the year 14,521 volumes were added to the library, making a total of 108,808 volumes at the close of the year. The library receives 2,234 scientific periodicals of which 442 are paid subscriptions, 907 exchanges and 884 free. The number of publications used and charged out was 55,896, or a daily average of 154 publications. The number of visitors recorded was 12,593.

UNIVERSITY AND EDUCATIONAL NOTES

AN additional $400,000 has been given to the University of Pittsburgh in addition to the gift of half a million dollars already contributed by Maurice Falk and the late Leon Falk for the construction of the Falk Medical Clinic in the university hospital group. This gift makes possible the immediate construction of the building.

AN anonymous gift of $200,000 has been made toward the projected pension fund of $1,000,000 for professors of Cornell University. The gift is contingent upon the raising of the remainder of the fund.

THE new engineering building has just been completed at the Pennsylvania State College. It contains quarters especially designed for the use of the department of architecture, a large hydraulic laboratory, offices and recitation rooms.

A. L. O'BANION, for the past five years instructor in electrical engineering at Cornell University, has been appointed professor of electrical engineering at Clemson College, South Carolina, to succeed Professor S. R. Rhodes, who has been made head of the division of electrical engineering.

DR. TEMPLE FAY, for many years associated with the neurological staff of the school of medicine of the University of Pennsylvania, has been appointed head of a newly established department of neurosurgery at Temple University.

JULIAN J. PETTY has been elected associate professor in the department of geology at the University of South Carolina.

DR. OYSTEIN ORE has been appointed to a full professorship of mathematics at Yale University.

DISCUSSION

LUNAR ECLIPSES IN GENERAL AND IN THE PHILIPPINE ISLANDS

IN the early days of scientific astronomy, lunar eclipses, aside from an imaginary importance as omens and portents, were the only means whereby differences in longitude could be ascertained with any approach to accuracy. The longitudes of Ptolemy's map of the world were mostly dependent on this kind

of celestial signal, and the first determination of the longitude of Cambridge, Massachusetts, is said to have been made this way. The study of the phenomena of lunar eclipses with the telescope soon showed that precise determinations by this method were impossible, because the *shadow edge* is as much a subjective as an objective phenomenon and vanishes in hazy indistinctness as telescopic power increases. The attempt to use transits of the two shadow edges, preceding and following, across lunar craters and other marks led to the discovery that the observed diameter of the umbra is larger than that computed from dimensions and distances in the system sun-earth-moon. This enlargement is taken into account in a rather arbitrary way in the prediction of lunar eclipses by the addition of a fraction of the diameter to its value computed on the hypothesis of simple shadow casting. The explanation of this enlargement is probably psychological. So the observation of lunar eclipses lost the respect of exact astronomy.

The frequently great beauty of the partially or totally eclipsed moon has, however, held the interest of all observing astronomers. The remarkable shadings, from pale blue through greens to copper, dull chocolate and dead black, are frequently very striking, and they demanded a scientific explanation. Kepler explained this *lumen secundarium*, which shines in the earth's shadow, as the result of the refraction of sunlight through the rim of atmosphere along the line of sunset and sunrise. The colors are due to absorption and scattering in our air, and are essentially the same as the beautiful glows which enliven evening skies, when cirrus clouds, cumulo-nimbus tops and snowy mountain summits shine rosy in the last rays of the departing sun.

The keen attention which lunar eclipses aroused when they were still practical means of determining longitude inevitably brought out the fact that this *lumen secundarium* was by no means constant from eclipse to eclipse, or even throughout the same eclipse. Sometimes the moon shone out from the earth's shadow with the maria as plain to the eye as at an ordinary full moon; again the shadow was so dense and dark that the immersed moon could not be seen. Thus, Sviatsky has found in ancient Russian annals accounts of thirty-nine lunar eclipses, and among them statements that on May 10, 1389, April 20, 1399, March 10, 1476, and September 16, 1624, the eclipsed moon was quite invisible in the sky; the same annals mention at other times the blood-red color which the eclipsed moon more frequently shows. An ancient prophet speaks of the sun being turned into darkness and the moon into blood, so that the red color was well known long ago; but these Russian records of *black* eclipses go back farther than any others known to the writer.

It was a natural conclusion that this variation of color and brightness of the moon in the earth's shadow must be due to variations in the transparency of the rim of atmosphere along the sunrise-sunset line, and that its spectrum must show something of the absorption effects of air at different altitudes above the ground. Probably A. Danjon, the skilful astronomer at Strasbourg, was the first to collect systematically the records of lunar eclipses, as phenomena of the terrestrial atmosphere, and to study them for correlation with other phenomena. In 1920 and later he published conclusions based upon seventy eclipses, in which he announced the discovery that the brightness of lunar eclipses is in general and almost in detail a function of the time of occurrence in the solar sunspot cycle. This conclusion has been vigorously attacked, on the ground that the sunspot cycle has been too irregular and that the correlation is too vague. In fact, also, Danjon's papers[1] give no references to dates and sources, merely conclusions, and so it is not possible to study his data independently. The present writer's interest in low-sun phenomena, of which the lunar eclipse is one example, led him to compile the published records of lunar eclipse observations, 1860 to 1922, and to publish all essential data so found in a pamphlet issued in 1924 by the Smithsonian Institution.[2] In this a three-step scale, 2, 1, 0, of brightness was applied to about fifty eclipses. The main conclusions were that the earth's shadow is darker in its northern half than in its southern, that the moon's varying distance has little effect, that winter eclipses (northern season) have been bright, spring eclipses dim, that volcanic dust has acted to make eclipses dark and that no relation was found between the brightness of eclipses and the solar cycle.

Since that time the writer has continued to collect data on lunar eclipses, both ancient and currently occurring, and has two papers on the eclipses of August 14, 1924, and June 15, 1927 (the latter in press). Besides, there has come to hand a forty-four page manuscript in the microscopic German handwriting of J. F. J. Schmidt. This has been carefully copied in type, complete except for a few places where as yet inspiration has failed for the interpretation of spelling or meaning. This manuscript extends from No. 1, January 26, 1842, to No. 28, December 28, 1879, observed at Eutin and Athens,

[1] *Bull.* Soc. Astron. France, 35: 261–265, 1921.
[2] Smithsonian Misc. Coll., Vol. 76, No. 9, publication No. 2751.

respectively. In all these years this most assiduous observer missed but one chance to observe an important eclipse; on the night of May 1, 1855, he was so absorbed in watching the great eruption of Vesuvius then in progress that "I entirely forgot about the eclipse."

And now there comes to hand No. 7 in Volume 1 of the Publications of the Manila Observatory, "Observations of the Brightness of Lunar Eclipses in the Philippines," by the Reverend Miguel Selga, S.J., director of the Weather Bureau. Father Selga has found time among the engrossing duties of a responsible and important official position to observe lunar eclipses himself, to stimulate many others, professional scientists and untrained observers, to do the same in the islands from Jolo and Zamboanga to Baguio and Sagada, and to collect from the records of the observatory observations of eclipses running back to January 7, 1871—of which hitherto we had observations only by Birmingham, at Millbrook, Ireland, and Schmidt, at Athens—and to May 12, 1873—recorded hitherto only by Tebbutt, in Windsor, N. S. W. Also, the Manila observation of November 26, 1890, seems to be unique.

Father Selga acted partly in consequence of a request by the writer, directed to the Reverend José Algué, S.J., then head of the Philippine Weather Bureau, for observations of the eclipse of February 20, 1924. He wrote numerous letters to friends throughout the islands and to persons associated with the Weather Bureau, and received many responses from observers all through the islands. In a region like that, where clouds are incessant, the more numerous the observers, the better, even though their scientific equipment may average not high. Father Selga has continued the same plan on the occasions of the later eclipses of August 14, 1924, December 8, 1927, June 3, 1928, and November 27, 1928. One of the observations came from distant Yap Island.

The results of this Philippine activity may be summarized thus: Father Selga, adopting the three-step scale of brightness, agrees to the grade 1 assigned by the writer to January 7, 1871, May 12, 1873, May 24, 1891, and April 22, 1902; to the writer's grade 2 assigned to February 29, 1896, and grade 0 assigned to March 21, 1894. The eclipses of October 26, 1920, and February 20, 1924, he calls bright; but he differs from the writer's grade 2 with regard to August 14, 1924, which his Manila records lead him to call rather dark. With regard to the distribution of light in the northern and southern parts of the shadow, he says, "In the cases here reported, the moon passed five times wholly north of the geometrical center of the shadow, three times wholly south, and it was central four times. Two cases of bright eclipses coincide with central passages and one case with a south passage."

Again, "The general tendency for bright eclipses to occur in winter is not contradicted by these observations." As to Danjon's solar cycle relation:

> (1) The minimum of solar activity did occur in 1923; (2) contrary to Danjon's prediction and expectation, neither the eclipse of February 20 nor the eclipse of August 13, 1924, was very dark, gray or very little colored. Of the two, the August eclipse was certainly the darker; while, according to Danjon, the farther away from the minimum, the greater should be the brightness. . . . The supposed relation between the solar cycle and the brightness of lunar eclipses is not clear, to say the least; many more observations under exceptional conditions are to be made before the relation can be accepted with certainty.[3]

WILLARD J. FISHER
HARVARD COLLEGE OBSERVATORY,
SEPTEMBER 6, 1929

A GENE FOR SUPERNUMERARY MITOSES DURING SPORE DEVELOPMENT IN ZEA MAYS

IN studying heritable functional sterility in maize, a case has been observed in which such sterility is due to supernumerary divisions of the young spores. This type of sterility is inherited as a simple Mendelian recessive.

The first and second divisions of the microsporocytes of sterile plants are apparently quite normal and result in the usual quartet of cells, each with a metabolic nucleus. In normal plants, the young spores undergo a growth period of at least several days, after which the nucleus divides vegetatively to form the generative and tube nuclei. In sterile plants, the young spores of the quartet immediately undergo a series of aberrant divisions. In the prophase of the first extra mitosis ten chromosomes appear. These ten chromosomes arrange themselves in the spindle and without splitting are distributed to the two poles, apparently at random. Cytokinesis follows and there result eight cells each of which usually has less than the haploid set of ten chromosomes. Each of these cells again divides in a similar manner, reducing the chromosome number still further. At least four such supernumerary divisions are known to take place in some cases, and probably many spores undergo even further division. These divisions are necessarily irregular and exhibit much lagging of chromosomes. Cells with only one chromosome in the spindle have been observed. Fragmentation of chromosomes appears to take place rather frequently.

[3] On page 3 the date September 4, 1913, should read 14—a typographical error for which the writer's pamphlet on the brightness of lunar eclipses is to be blamed.

Megasporogenesis in sterile plants has not as yet been studied cytologically. Since all but a few of the female gametes are non-functional, it is tentatively assumed that megasporogenesis is probably essentially similar to microsporogenesis. The progeny of sterile plants (sterile x normal) appear for the most part to be normal diploids. Such would be expected to be the case if it is assumed that at least the full haploid set of chromosomes is necessary for the production of a functional gametophyte.

GEORGE W. BEADLE

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APPEAL FOR SAMPLES OF TREE SEEDS

THE Waldsamenprüfungsanstalt (forest tree-seed testing station) at Eberswalde, Germany, has for decades been a leading institution for the scientific study of tree seed. During the last six years Professor Dr. Werner Schmidt, the present director of the station, has made notable contributions to our knowledge of seed, especially of the internal, physiological differences in seed of different climatic races of the same species. This station is probably the only seed control station in the world devoted exclusively to forest tree seed. It cares for all the states of Germany, and consequently has a large volume of routine work, for which research must give preference. The staff now consists of two assistants, besides the director, and from three to five laboratory assistants and clerical aids (women). The annual budget for all operating expenses aside from the salaries of the male staff is at present only 3,000 marks ($750). Thus very small funds have been available for experimental work, which has precluded the purchase of material. Recently, owing to its rapid growth in central Europe, great interest has attached to Douglas fir (*Pseudotsuga taxifolia*). Northern white pine (*Pinus strobus*) is also fairly important in Europe. At present there is no systematic work being done in America on tree seed at all comparable to that under way at Eberswalde. Studies of the behavior of American species should prove very interesting. Any one in a position to do so will do the station a great favor by forwarding small samples of tree seeds with data about their place of origin. This may make possible important discoveries of the characteristics of our own species. Samples of fifty grams are sufficient for all except the largest seeded species, and should be addressed directly to Professor Werner Schmidt, Eberswalde, Germany. If possible seed of this autumn's crop should be sent; in any case full information as to where the seed was collected, altitude, notes on the climate, such as length of growing season, temperature of the summer months, etc., of the place of origin and the year and month of collection should be sent. It is not necessary that the seed be winged or cleaned; in fact cones may be sent if preferred. Several samples of the same species from widely varying regions and elevations are especially desired. It is hoped that many foresters, botanists and others may be able to cooperate by sending in samples.

HENRY I. BALDWIN

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NEWSPAPER SCIENCE

THE following article appeared in the New York *Times* of September 1, 1929:

SNAKE-KILLING MONGOOSES A PLAGUE TO PORTO RICO

HARRISON HECKMAN, of Augusta, Me., a field representative of the Red Cross, who has spent much time in Porto Rico, says the island has a problem: How to get rid of its mongooses. Not so long ago boa-constrictors thrived there, interfering greatly with the work of the coffee and sugar plantations. They also killed men and beasts. Even the natives hesitated to venture into the forests. So a shipment of mongooses was obtained from Asia.

Because of their fecundity only males were procured. These went about their business very thoroughly and systematically. In a few years they had cleared the island of most of the boa-constrictors. But they crossed with native rats and have multiplied to such an extent that they are devastating crops. How to get rid of them is a serious problem.

When a mongoos meets a boa-constrictor it takes up a position directly in front of it and apparently makes up faces. The snake, in its ignorance, thinking it is going to have an extra large rat for dinner, immediately throws out its poison. The mongoos, anticipating this, side-steps.

When the enraged serpent has emptied its poison sack the killer sits on his head, obtaining a firm hold with its teeth. The frenzied serpent makes a terrific struggle but in the end has to give up, exhausted.

After reading the above one is tempted to ask how Mr. Heckman learned so much that is not true. I have examined Schmidt's "Amphibians and Land Reptiles of Porto Rico"[1] and fail to find any record of the fierce (?) and poisonous (?) boa-constrictors of Porto Rico, but probably they were destroyed by the remarkable mongoos before Schmidt visited the island. island.

MEL T. COOK

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[1] Scientific Survey of Porto Rico and the Virgin Islands, New York Academy of Sciences, 1928.

SCIENTIFIC APPARATUS AND LABORATORY METHODS

BLOCKING-OUT UNDESIRABLE BACKGROUNDS IN PHOTOGRAPHS

I WISH to bring to the notice of those who use photomicrographs for illustration a method of blocking-out the backgrounds of their negatives by means of cellophane sheets. This thin, transparent material now commonly used for wrapping cake, candy-boxes, etc., comes in sheets 35 x 40 inches and in a variety of colors. The ruby red cellophane, used for the present purpose, is absolutely non-actinic and so extremely thin that it permits perfect contact between negative and printing-paper. I cut up the sheets into pieces corresponding in size to my negatives, in my case 4 x 5 inches.

One of these is laid on the film side of the negative and the outline of the photo is traced on the cellophane with pen and ink. Any error in the ink outline can be corrected by drawing a new line without bothering to remove the inaccurate one, as the non-actinic cellophane makes such lines invisible in the print. The true outline is then cut out by means of dissecting-scissors or a sharp scalpel or a very finely pointed needle. It is best done over a piece of white blotting-paper.

The opening is then placed over the photo and the two outlines are accurately adjusted. A minute drop of thick styrax, such as is used in microscopic mounts, will fasten the four corners of the cellophane film to the face of the negative.

By this method perfect accuracy in blocking-out backgrounds is secured in far less time than by the common one of painting out with opaque red or India ink. In the case of diatom photos the improvement in the finished prints is very great, for on account of their translucence unblocked backgrounds are usually dense and greatly detract from the sharpness of the photo. The almost infinite variety in diatom outlines also makes blocking-out by the old method a difficult and slow task.

It should be added that objects with circular outlines, a form common among diatoms, can be most easily outlined by measuring the diameter of the circle and cutting out an opening with a pair of compasses, the tip of one leg being sharpened so as to cut through the cellophane film. Obviously, also, this material is ideal for mats around pictures where complete blocking-out of the background is not desired.

Negatives so prepared can be stored without any appreciable loss of space.

ALBERT MANN

WASHINGTON, D. C.

MOUNTING SERIAL SECTIONS

SEVERAL years ago the author devised a method of applying balsam and cover-glass to slides of serial sections which, while apparently not in use elsewhere, possesses several advantages over the technique usually employed. This method is as follows.

The slides of stained and cleared sections are passed through a jar of clean xylol and removed one by one without draining to a piece of toweling paper, upon which they are laid back down. Enough thick balsam is then dropped on the sections to insure that considerably more will be present than the amount actually needed. The cover-glass is then quickly placed upon the balsam. The large amount of balsam present and the undrained xylol still upon the slide insure quick and complete displacement of the air. Very seldom will any bubbles form.

After an interval of a few seconds the slide is stood on edge in a small slide box, lined on the bottom with towel paper. The superfluous balsam and xylol drain from the slide and are absorbed by the paper. It is often desirable to pipette xylol onto the paper to insure contact between it and the slides and start the absorption. In my own use I find wooden slide boxes (twenty-five slides capacity), cut in half so that two trays holding twelve each are formed, very handy. The box is then placed with slides *on edge* in a Tharaldsen "Columbia" oven, and the temperature increased just enough to insure seepage of the balsam. Additional xylol may from time to time be pipetted upon the paper. If the heat is not too great there will be no danger of too much balsam running out and leaving air spaces. Any bubbles that may have occurred in mounting will quickly work out. Capillary attraction insures that exactly the correct amount of balsam remains and no more. The cover will be drawn down tightly, and any sections which have not adhered evenly to the slide will be pressed down flat. There is no necessity at any time for balsam to soil the outer surfaces of the preparation.

After a few hours in the oven the upper edges of the slides will have dried, and then heat may be increased, as far as is felt safe for the material and stain, to expedite the drying. When the slides have dried sufficiently to be removed from the box the only cleaning required is a light wipe along the lower edge with a cloth moistened with xylol.

This method is much quicker and easier than the ordinary way, and guarantees the closest possible contact between slide and cover—a great advantage in delicate work with high-power objectives. The slides require practically no cleaning from superfluous balsam when dry and are hard enough for use within twenty-four hours from the time of preparation. The method is, of course, limited to the use of cover-glasses approximating the width of the slide.

JUSTUS F. MUELLER

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SPECIAL ARTICLES

THE LAWS OF DISTRIBUTION OF PARTICLES IN SUSPENSION

THE motion and distribution of fine particles suspended in a fluid are subject to laws which have been derived by statistical methods by Einstein and extensively studied experimentally by Perrin. Their results are well known and frequently cited. I wish here to point out a very much simpler derivation than Einstein's of a slightly more general law than Perrin's. The reasoning is thermodynamic rather than statistical.

Throughout any aggregate of particles in thermal equilibrium, the kinetic energy of thermal agitation is everywhere RT/M calories per gram (R gas constant, T absolute temperature, M molecular weight), otherwise there would be a net flow of heat which is contrary to the assumption of uniform temperature. The size or kind of particle is assumed to be immaterial and it may be either molecular or microscopic. The pressure corresponding to this energy, which we shall call the kinetic pressure

$$(1) \qquad \varkappa = CJRT/M \text{ dynes/cm}^2$$

is the integrated kick of all the molecules or particles of a given class (defined by M and concentration C) or of all classes. For microscopic particles it is the pressure due to Brownian movement which is caused by and is in equilibrium with the thermal agitation of the molecules of the suspending fluid.

The weight of such an aggregate of particles is

$$(2) \qquad W = Ckg \text{ dynes/cc}$$

where C is concentration in grams/cc, $g = 980$ dynes/gram and $k = 1 - \varrho_1/\varrho_g$, ϱ_g being the density of the grains and ϱ_1 that of the suspending fluid.

The pressure gradient $d\varkappa/dz$ depends upon the variation of the ratio CT/M with depth. If this ratio is the same at all depths, the kinetic pressure must be uniform and the gradient zero. In a true solution C and M are both constant if the temperature is uniform and CT = constant (Soret effect) if it is not. Even in a suspension of fine particles CT/M may be constant if, at various levels, the concentration is proportional to size of particle, *i.e.*, if the number of particles in unit volume is constant. In general, an aggregate of particles will be in equilibrium distribution if the pressure gradient upward just equals the weight of suspended material in unit volume

$$(3) \qquad d\varkappa/dz = dw$$

or, by substitution from (1) and (2), if

$$(4) \qquad \frac{d \log (CT/M)}{dz} = \frac{Mkg}{JRT}$$

which is the most general equilibrium condition. In the special case of uniform mass of particle M and uniform temperature T, (4) reduces to $d \log c/dz = Mkg/JRT$ which may be integrated giving

$$(5) \qquad \log (C/C_0) = Mkgz/JRT$$

the integration constant yielding C_0, the concentration at the surface where $z = 0$. (5) is the equivalent of Perrin's equation.

If the pressure gradient in a suspension is greater than its immersed weight then it will diffuse upward to the surface; if less than the weight it will settle according to the generalized Stokes' law with the velocity

$$(6) \qquad v = \frac{2}{9} \frac{r^2 \varrho g}{\eta C} \left(Ckg - \frac{JRT}{M} \frac{dC}{dz} \right).$$

The expression bracketed is the resultant force acting on all the particles in unit volume. When the concentration gradient $dC/dz = 0$, (6) reduces to the ordinary form of Stokes' law. This and other equations above may be put in different forms by using the substitutions $C = mN$, $M = V\varrho_g = M$ times the mass of the hydrogen atom, 1.66×10^{-24} gram.

From the form of (6) it is evident that velocity of fall is very sensitive to size of particle. It may readily be zero or even negative (upward) for the smaller particles. As each size of particles falls, smaller particles are not only left behind but tend to diffuse upward.

The kinetic pressure theory of suspensions here developed assumes clean reflecting walls for the containing vessel. A soft or muddy bottom, for example, quite actively assists in pulling down a suspension. Light pressure also effects settling, fine suspensions depositing on the far side wall of a tube exposed to strong horizontal illumination.

P. G. NUTTING

WASHINGTON, D. C.

THE OCCURRENCE OF VIABLE COTTON ROOT-ROT SCLEROTIA IN NATURE

A TRUE sclerotial stage of the cotton root-rot fungus, *Phymatotrichum omnivorum* (Shear) Duggar, was first observed in Arizona by C. J. King and H. F. Loomis in September, 1928, in laboratory cultures.[1] These observations were later confirmed by the writer in Texas, and such sclerotia have also been discovered in the soil, first in northern Texas at the U. S. Cotton Breeding Field Station near Greenville, in Hunt County, and later in southern Texas at the U. S. Field Station near San Antonio. As the sclerotia formed readily and abundantly in culture jars containing layers of sterile soil, sand and cotton roots,

[1] In press in the *Journal of Agricultural Research*.

after intervals of from thirteen to fourteen days, it was believed that careful examination of the soil of fields infested by the fungus would ultimately reveal the true sclerotia under natural conditions. Although various sclerotium-like bodies similar in their general morphology to the sclerotia had been found in the soil from time to time during the winter and spring months, attempts to recover the fungus in culture from such bodies were not successful. Accordingly, it was decided to make deeper and more careful excavations of infested soil areas.

After studying the infection maps for the previous years, excavations were made on May 24 near the center of a station plot designated as D-7. This particular plot was planted to cotton in 1928 and is fallow this season. The infestation over this entire area last season was exceedingly heavy and more or less continuous, with little if any well-defined individual spots.

Soil samples were taken at depths of twelve, sixteen and thirty-two inches and the soil particles carefully examined under suitable hand lenses. Several sclerotia were found free in the soil, unattached to any plant material, at different depths. One sclerotium showed even under the low power of the microscope the characteristic strand hyphae and acicular branches of the root-rot fungus. The sclerotia were mostly single, averaging slightly less than two millimeters in diameter, but some were attached or paired. All the sclerotia obtained from these excavations were placed in small vials and immediately removed to the laboratory for tests of viability. Cultures were obtained from sclerotia collected at depths of twelve and sixteen inches.

The sclerotia were surface sterilized for forty-five seconds in a 1:1000 solution of mercuric chloride, dipped for a brief interval in 50 per cent. alcohol, washed in sterile distilled water and cultured on acidulated corn-meal agar slants in test-tubes and Petri dishes. Two days later they were removed to similar tubes and Petri dishes containing non-acidulated corn-meal agar. On May 29, three days after the cultures were made, evidence of germination was apparent in two of the tubes, the young hyphae appearing first white in color, somewhat rigid and bristly. On June 4 mycelial strands were plainly visible on the sides of the tubes, extending several millimeters above the media, of a yellow to light ochraceous buff color, such as characterizes root-rot hyphal strands after a few days' growth on a carbohydrate medium. Microscopical examinations were made of the cultures on June 6, and the large-celled, Rhizoctonia-type of mycelium was observed, with two-forked and three-forked branches arising from the large cells and becoming flexous and delicate as growth continues. On June 10 transfers were made to flasks containing dead sterilized cotton roots and a slight excess of moisture. On this medium typical strand hyphae, acicular hyphae and pseudosclerotia were formed in eight to ten days, with the latter arranged in a typical tree-like pattern and attached to the strands on the walls of the flasks. This form of growth is typical of *Phymatotrichum omnivorum*.

On June 15 transfers were also made of the mycelium which the sclerotia had produced on the agar slants to wide-mouth pint bottles containing alternating layers of sterile soil, sand and cotton roots. These cultures were incubated at 29.5° C., and, after a growth period of thirteen days, produced true sclerotia identical in their morphology to those produced in other cultures of the fungus isolated from the roots of infected cotton plants at the Greenville Station during the season of 1928.

One of the first sclerotia obtained, at a depth of twelve inches, was fixed in chromo-acetic acid solution, dehydrated, imbedded in paraffin and longitudinal sections prepared eight microns in thickness. These were stained in Flemming's Triple Stain and in iron-alum hematoxylin. They reveal the same general type of structure as in other sclerotial fungi and in the cotton root-rot sclerotia which have been produced heretofore in culture. They are round, oval, ellipsoid, reniform or variously constricted, and often flattened or depressed around the strand connections. The sections reveal a distinctly cellular structure, usually with two layers of smaller thick-walled epidermal cells, whereas the cells toward the center are parenchyma-like, with thin walls and of irregular shape.

Additional histological and morphological studies of sclerotia formation by the root-rot fungus, and infection experiments with cultures originating from the sclerotia obtained from the soil are in progress.

The function of the sclerotia as the hold-over stage of the fungus is indicated. The first sclerotia produced in cultures at Greenville were recorded on January 3, 1929, and are still viable in July, 1929, after remaining seven months in the incubator.

Summary

Viable sclerotia of the cotton root-rot fungus, *Phymatotrichum omnivorum*, have been found under natural conditions in the soil of infested cotton fields in Texas, showing that this fungus is a soil organism not restricted to living roots of susceptible host plants, but having an independent means of over-wintering and dissemination.

D. C. Neal

U. S. Department of Agriculture,
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SPECTRUM FOR TESTING PARTIAL COLOR-BLINDNESS

THE rainbow hues obtained when pure white light is passed through a prism are the best colors to be used in testing cases of partial color-blindness, Sir John Herbert Parsons, of the University of London, declared at the dedication of the Wilmer Ophthalmological Institute at the Johns Hopkins University. Sir John, one of the world's authorities on color vision, represented the ophthalmologists, or eye specialists, of England at the dedication exercises.

Color-blindness may range all the way from total inability to distinguish colors, when the subject sees everything as gray and black, to mild forms in which the subjects have difficulty in distinguishing one or two shades. Confusion of red and green is a particularly common form, and a highly dangerous one when it occurs in employees of navigation or railway lines. Colored lights and flags are so universally used for signals that public safety depends on accurate testing of railroad and navigation employees. In cases that are not very pronounced, it is extremely difficult to make accurate tests, and it is for these cases especially that Sir John recommended the use of spectral colors.

The Board of Trade of London has a special lantern for testing public employees in which the colors are all shown with the same degree of luminosity or brightness. This lantern is not allowed to be sold on the market, however. The lantern was devised because sailors and railroad men objected to matching colored wools, which they considered altogether too feminine. The wools are commonly used for other types of patients. Both lantern and wool tests are not infallible, Sir John commented, but a trained examiner will be able to tell whether color-blindness exists, even if he can not tell the degree by these means.

Color-blindness is often called Daltonism from John Dalton, the great English scientist, who discovered it. Dalton himself was a Quaker and shared his sect's abhorrence of bright colors. After receiving the degree of doctor of laws, he went about the streets wearing a crimson robe of that doctorate, quite happy and quite unconscious of the agitation he was causing among his Quaker friends. He himself was color-blind and did not know the color of the robe he wore. It was 50 years after Dalton's discovery of the condition before any serious efforts were made to eliminate color-blindness from the personnel of ship and train crews.

WOOD ALCOHOL BLINDNESS

THE story of the blindness that comes from wood alcohol has not yet been completely told. A further study of this problem might well be made by the newly dedicated Wilmer Ophthalmological Institute as suggested by Dr. George E. de Schweinitz, of the University of Pennsylvania, in his address at the dedication exercises.

Physicians now generally believe that it is not the wood alcohol, but some impurity in it, possibly fusel oil which is nearly always found in commercial wood alcohol, that causes the blindness. The bad liquor prevalent in recent years often contains wood alcohol and has been the cause of much wood alcohol poisoning and blindness. However, wood alcohol may also be inhaled or it may be absorbed through the skin. This is an important hazard in certain industrial operations.

The dedication of the new Wilmer Institute, devoted to the study and treatment of eye disease, Dr. de Schweinitz considered an outstanding contribution to American ophthalmology. Other landmarks mentioned were the invention of bifocal glasses by Benjamin Franklin in 1764 and the establishment of the first eye infirmary in this country at New London, Connecticut, in 1870.

One of the first operations for cataract performed in this country was done by Edward Reynolds, of Boston. On his return from Europe where he had been studying the eye and its diseases, he found his father suffering from cataract. According to his own account, he "went to his surgery, offered a prayer to the Deity, took a glass of sherry and went ahead to do his best."

Routine examination and care of the eyes of all patients entering the hospital first was established in this country at the hospital of the University of Pennsylvania Medical School by Dr. Charles Norris of that institution. This was a particularly important step in the development of ophthalmology according to Dr. de Schweinitz. Further development of this medical specialty would come through further cooperation between eye specialist, regular physician and pathologist, the latter being the specialist who studies in the laboratory the changes brought about in the body's tissues by disease. Conditions at the new Wilmer Institute are particularly fortunate both for the individual patient and for the development of the science of ophthalmology.

THE USE OF BACTERIOPHAGE

EQUIPPED with a brand new weapon against disease, scientists have failed to get the hoped-for results with it because they have not known exactly how to use it. Bacteriophage, the potent germ killer, discovered by the French-Canadian, Dr. F. d'Herelle, now a Yale professor, gave promise of being the world's greatest disease-conqueror. It has fallen short of fulfilling this promise because the men who had to use it have not understood it well enough to get uniformly good results.

The age of the material, the method of administration and the amount of the dosage are points that must be settled in order to get the most successful results with this new weapon, one of its advocates, Dr. N. W. Larkum, of the Michigan Department of Health, told a group of fellow scientific men, at a meeting held in Indianapolis on October 18. The group to which he spoke was composed of men who have devoted themselves to the study

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of disease germs and means of combatting them. This group is an informal organization, without any name, which meets several times a year in order to exchange views and notes of progress on the members' work.

Bacteriophage kills germs in a test-tube and actually dissolves them. The hope of its discoverer and sponsors is that it will do the same thing to germs in the human body. In some cases it has killed the germs that were attacking the body, in others it has failed to do so. Dr. Larkum believes that the failures occur when the phage is used incorrectly, through ignorance of the best conditions for it to do its work.

Possibly the phage is potent only at a certain stage of its development. Up to now, the age of the material has not been given any consideration. The method of administration has been chosen with a view to getting the stuff into contact with the bacteria. Dr. Larkum suggested that it may be better to bring the material into contact with the susceptible tissues of the body, in order to make them immune to attacks of the disease germs and thus check the spread of the germs through the body. The matter of how large a dose to give also needs to be determined scientifically. "At present the selection of the dosage is entirely arbitrary, based upon some success attending a given dose. It is entirely logical to conclude that as many failures have been due to excessive dosage as have been due to an insufficient amount. Until further light has been shed upon these various factors in bacteriophage therapy, one is scarcely justified in condemning the method."

EMOTIONS AND DISEASE

NOBODY really overworks as far as mind and body go, but we live at such a high emotional tension that we become tired and jaded and require violent stimulation to keep us going. Also, this high emotional tension is the cause of a number of diseases, Dr. Charles P. Emerson, of the Indiana University School of Medicine, said at a recent meeting of the New York Academy of Medicine.

"Under certain conditions a strong emotion can inflict a physical injury just as truly as can a knife," Dr. Emerson said. "The injurious effect of a long maintained depressing emotion has never been appreciated. We endure well the effects of strong emotions, if only their duration is brief or their qualities varied. That the depressing, contractile, paralyzing emotions called fear, apprehension, worry, etc., weigh heavily in the balance against a patient during the course of an infection has long been suspected, but since these phenomena can not be weighed, measured nor rendered objective, we can not at this point consider them seriously. The effect of these emotions on the glucose tolerance of a previously well-standardized case of diabetes mellitus can, on the other hand, be measured in terms of grams of sugar in the urine, in milligrams of glucose in the blood-stream, and of units of insulin necessary to restore the sugar-free condition."

Dr. Emerson urged physicians to consider more the emotional and psychological aspects of disease than has been done in the past. This new phase is just as much a part of regular medicine as are the physical and biochemical aspects with which physicians have long since become familiar.

MANGANESE BY VACUUM DISTILLATION

DISTILLATION gets most of its publicity as a result of its more or less disreputable employments, but it achieves most of its real usefulness in the world in technical laboratories that few people ever hear about, at tasks which only chemists can think up for it. Its newest job is to get manganese, one of steel's most important alloys, out of its ores in an almost absolutely pure condition. An improved apparatus for doing this was described at a meeting of the Metallurgical Advisory Board, in Pittsburgh, by Dr. James B. Friauf.

Distillation of any kind depends on boiling the material to be purified, and then condensing the steam or vapor. This is simple enough with water, which boils at 100 degrees Centigrade, and with alcohol, which boils at an even lower temperature. But the boiling-point of manganese at atmospheric pressure is about 1,900 degrees, and even in an almost complete vacuum it is still in the neighborhood of 1,000.

To accomplish this difficult distillation, Dr. Friauf encloses a magnesia crucible full of manganese ore in a chamber of fused silica. Around the crucible is a coil of water-cooled wire, through which a high-tension, high-frequency alternating current is passed. This induces what are known as "eddy currents" within the coil, and this induced electricity heats the manganese in the ore above the boiling-point, causing it to pass off a vapor. The gaseous manganese rises from the crucible through a magnesium chimney, and condenses into a solid again on its cooler walls. From there it is recovered as a solid metal, so hard that it can scratch glass.

THE DISCOVERY OF RUINED MAYA CITIES

IN discovering four ruined Maya cities dotted on the great unexplored area of the Yucatan peninsula of Mexico, the airplane flights of Colonel and Mrs. Charles Lindbergh and Carnegie Institution archeologists have given a better conception of the line of growth of the ancient Maya civilization.

The newly discovered cities lie in a line stretching northeastward from the Old Empire region of the Maya, located largely in what is now the state of Guatemala, where the civilization emerged about the time of Christ. The newly found ruins connect this older area with the New Empire region, on the north end of Yucatan peninsula. Chichen Itza is the outstanding example of this New Empire culture.

Flying over unmapped dense tropical jungles, the Lindbergh party sighted three ruined cities definitely determined to be "new." A fourth city, one of the largest found, may be a new discovery, but it may prove to be one seen by Dr. Thomas Gann some years ago in the vicinity of Lake Bacalar.

Many months and perhaps years will be required to investigate and explore the cities located from the air. Many weeks of hard travel by land will be necessary to place land parties at the ruins. But when the broken temples are rescued from the enveloping vegetation, there

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will be available a better idea of the spread of the Maya, who more than fifteen centuries ago rose from primitive simplicity to a complex state with highly developed religion, government and monumental architecture. How and when the center of Maya culture shifted from the Old Empire region to the New Empire has been one of the unanswered questions. The connecting cities now found will probably supply the answer.

Nearly as exciting to archeologists as finding new ruins is the fact that no cities were found in the area of the Mexican state of Campeche, which was surveyed on the second day's flight from Merida southward. Coupled with the discovery of the ruined cities farther to the east, the absence of Maya settlement sites in the western part of the Yucatan peninsula is significant in explaining the spread of the Maya civilization.

The four discovered ruins are located in flat country. From the air the raised temple mounds could be seen twenty miles away in some cases. But giant trees and dense vegetation rise about a hundred and fifty feet to shroud the glistening white stones with which time has dealt severely. Only by flying low over the area could the central temples of the cities be seen and studied from the speeding airplane.

The first ruined city, seen on the first day's flight, is located in the southeast corner of the state of Campeche, some fifty miles from the Guatemalan boundary line. Situated in the heart of uninhabited jungles, far from lakes of any kind, it will present a difficult objective to land parties.

Of the three cities discovered in Quintana Roo during the most fruitful fourth day flight, two are located sufficiently near lakes to allow early exploration by parties transported by air to these lakes. The city near Lake Bacalar is probably more extended in area than the others. The last city discovered and the one nearest the coastal ruins of Tulum is the least accessible of the three due to the absence of water near it on which an airplane might land.

Dr. A. V. Kidder, director of the Carnegie Institution's archeological work, who flew on the last three days, was disappointed in not being able to see from the air traces of great stone highways connecting Maya cities.

The flights over Coba on the fourth and fifth days of the joint Carnegie Institution and Pan-American Airways explorations were of historical interest because the city has been seen by white men on only two occasions before this time. In 1926 Dr. Kidder and a companion, J. Eric Thompson, now of the Field Museum, visited the city, and not until last February when Colonel Lindbergh located it during a Pan-American Airways trail-blazing flight was it seen again by a white man.

Dr. Kidder indicated on his return to Washington that air travel will become a routine part of the Carnegie Institution's archeological work in the Maya region as soon as funds can be secured for a light amphibian airplane and equipment. With the use of Pan-American Airways bases at Cozumel Island and Belize, a two-year program of detailed aerial exploration could be carried out for about $50,000. Colonel Lindbergh will act as an adviser to the archeologists on the aeronautical aspects of the work.

ITEMS

A NEW petrified forest, the only one so far discovered with the trees lying as they fell millions of years ago, is reported by the U. S. Bureau of Reclamation. It was found by a road-building expedition on the Lower Yellowstone reclamation project, about three miles southwest of Savage, Montana. The petrified forest covers several acres. Some of the trees are ten feet in diameter and over 100 feet long. They all lie with their tops pointing in the same direction, indicating that they may have been blown down by a storm. The shape of the trunks suggests that they belonged to the same forests that supplied the materials for the nearby beds of coal.

A VOLCANIC island formed last year by a submarine eruption in Sunda Strait, near Verlatern Island, Java, has now disappeared beneath the sea, according to information received at the U. S. Hydrographic Office by the Dutch authorities.

THE sudden birth of a towering waterfall 300 feet high is reported from Iceland by an English traveler writing from Reykjavik. It is due to the breaking down of an ice dam across a lake on top of a glacier-capped mountain known as Lang Jökull, which lies in western Iceland not far from the famous Geysir, first known of all geysers of the world. According to the statements of farmers in the neighborhood, the lake burst its glacial barrier during the course of a single night with a noise like thunder, and so flooded the little river Tungufljot that it carried out a concrete bridge.

EARTHWORMS longer than a man and an inch in diameter are reported in *Nature* as the quarry of a naturalist's hunt in southeastern Australia. Average specimens range from four to six feet in length, and one nine feet long was observed by Charles Barrett, member of the expedition. An extreme length of eleven feet was reported though not seen on this expedition. The worms make loud gurgling noises when they retire into their burrows on the approach of a possible enemy. Their greenish-translucent eggs have tough, horny shells, and are from two to three inches in length.

THE ancient history of Samarkand, famed city destroyed by the Mongol conqueror Genghis Khan in 1220 A. D., is being dug out of the earth by a Russian archeological expedition. Results of the present season's work have been completed and nothing more can be accomplished until next spring. Clay utensils bearing a strong resemblance to Roman vases have been unearthed in the lowest levels of earth reached by the spade. These raise the question of contact between Rome and this eastern center. The finds demonstrate that the city had its origin as far back as the second century. Well-preserved houses from a later period, containing coins, lamps and household utensils, have been excavated. Art panels and reliefs of considerable beauty have been recovered and are now in the Museum of Samarkand.

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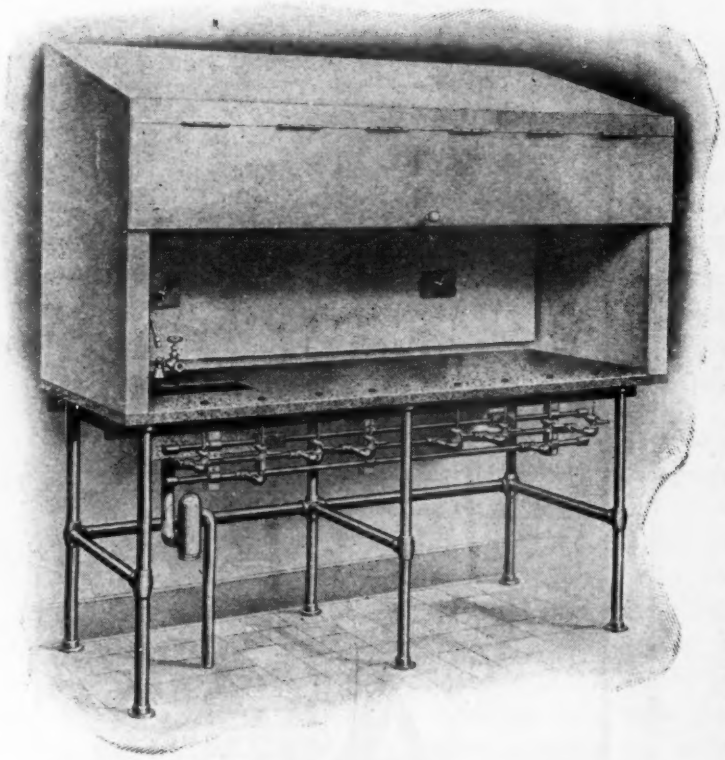

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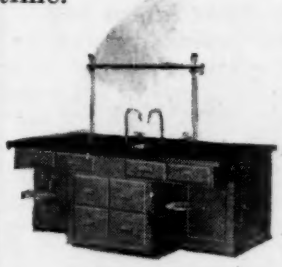

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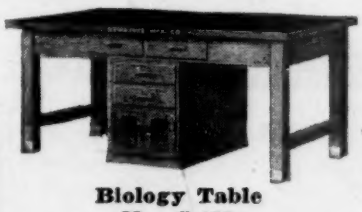

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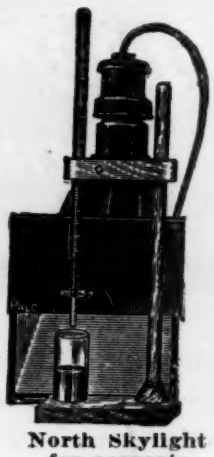

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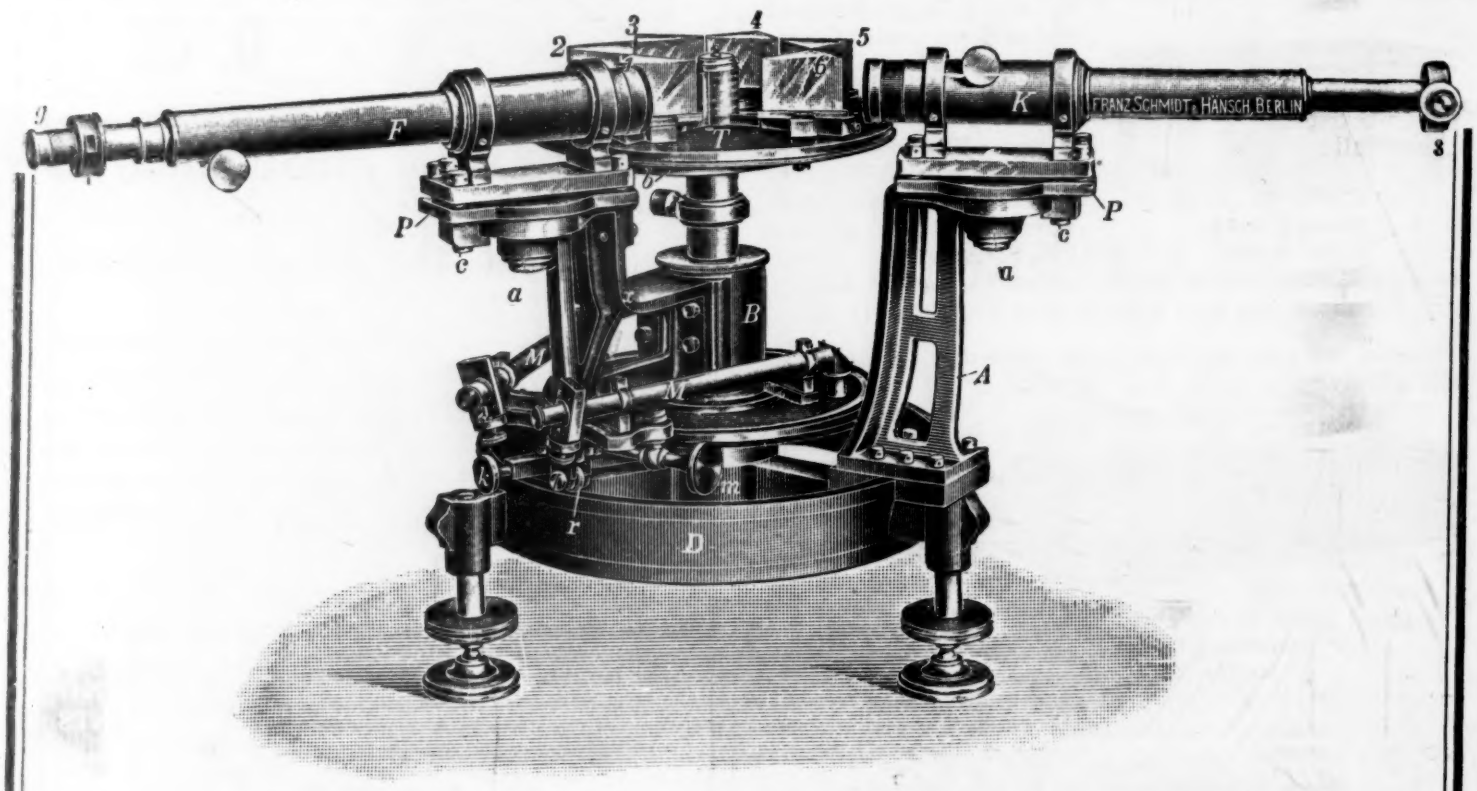

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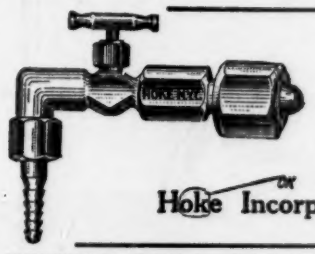

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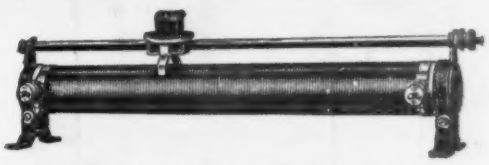

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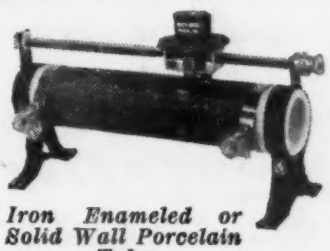

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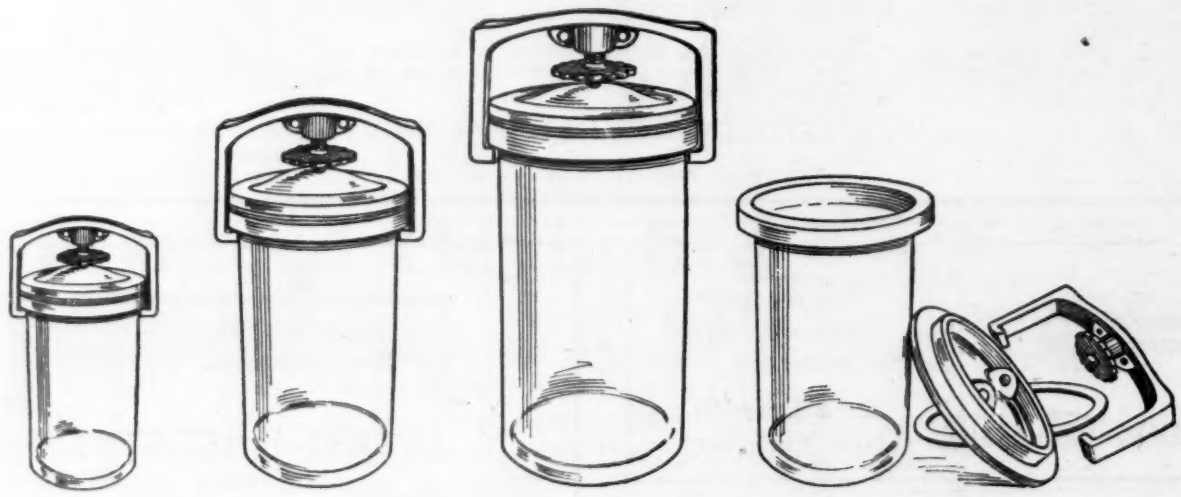

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